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PRINCIPAL INVESTIGATOR: Berlinda S. Martinez
James H. Stuhmiller, Ph.D.

CONTRACTING ORGANIZATION: Jaycor
San Diego, California 92121-1190

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Blast Overpressure Program
Kirtland Air Force Base

CITATION DATABASE

Version 1.0

Prepared by:
Berlinda S. Martinez
JAYCOR
9775 Towne Centre Drive
San Diego, California 92121-1996

Prepared for:
Commander
US Army Medical Research and Materiel Command
ATTN: MCMR-RMC
Fort Detrick, Maryland 21702-5012

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BLAST OVERPRESSURE PROGRAM
KIRTLAND AIR FORCE BASE

CITATION DATABASE

JAYCOR
9775 Towne Centre Drive
P. O. Box 85154
San Diego, CA 92138-5154

First Edition – June 1999

This database contains a comprehensive list of citations that were generated by the Blast Overpressure Program (BOP), Kirtland Air Force Base, New Mexico, from 1951 through 1998. The database was created using Microsoft Access97.

The purpose and use of this database is two-fold:

1. To compile a comprehensive bibliography of the documents generated by the researchers at the BOP from 1951 through 1998, and
2. To create a database in a form wherein information could be easily retrieved by a multitude of identifiers, for example, if an individual were interested in only retrieving the documents that used the rat for a model, exposed to a Friedlander wave, single exposure, high explosives, with primary blast as the target injury at a threshold level.

A hard-copy is provided. Section I contains a copy of the database sorted alphabetically by author. Section II contains a copy of the database sorted alphabetically by title. Section III is sorted numerically and includes the abstracts of each citation. Finally, Section IV contains a copy of the Animal Information Report.

Note—

This first edition may contain entries that upon review may be deleted from final version.

The data entry and revision to this database is on-going. A revised version of the diskette will be provided, as required, as significant additions/changes are made.

BLAST OVERPRESSURE PROGRAM
KIRTLAND AIR FORCE BASE

CITATION DATABASE

NOTES

The database was created using Microsoft Access97. It consists of nine tables which are updated by using one of two forms. Five report designs are included and allow the user to print the data into lists which are sorted by either title, author, number or date.

The two forms used for updating the database are:

1. Data Entry Form, and
2. Animal Information Form

The Data Entry Form contains the citation information—

Author(s)

Title

Source

Keywords

Abstract

The Animal Information Table contains discrete information for each citation—

ANIMAL INFORMATION, including:

Animal ID (form sequence no.)

Model (one of the following fields is selected)

Rat	Fish
Mouse	Man
Guinea Pig	Sheep
Goat	Dummy, anthropomorphic
Bovine	Model, mathematical
Cat	Swine
Dog	Rabbit
Monkey	Hamster
Bird	

Number of Animals

BLAST WAVE PARAMETERS, including (a field is chosen from each category):

Blast Type
- Friedlander
- Complex
- Shock tube, open
- Shock tube, closed
- Underwater
- Impact
- Drop, freefall
- Electromagnetic pulse

Blast Wave
- Single
- Double
- Multiple
- Reflected

Blast Source
- Nuclear
- High explosives
- Fuel-air explosives
- Shaped charge
- Air gun
- Air driven
- Gas

INJURY PARAMETERS, including (a field is chosen from each category):

Injury Type
- Primary
- Secondary
- Tertiary
- Radiation
- Thermal
- Blunt trauma
- Combined injury
- Auditory
- Impact
- Miscellaneous

Injury Level
- Suprathreshold
- Subthreshold
- Threshold
- Severe
- LD50
- Mortality
- P50
- Performance decrement

Section I.

BOP Kirtland Database
Sorted Alphabetically by Author

BOP Kirtland Data Sorted Alphabetically by Author

K0350

Behind Armor Effects Data Bases

Rough draft report, KAFB.BAE 1987, Statistics Group, Los Alamos National Laboratory, March 1988

K0121

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K0192

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DASA Data Center Special Report 27, Blast and Shock Simulation Facilities in the UK, Canada, and the US, DASA-1627, Defense Atomic Support Agency, Washington, DC, April 1965

K0356

Proceedings Event Dial Pack Symposium Report

Vol. II, The Technical Cooperation Program, Defence Research Board of Canada, Alberta, Canada, March 1971

K0353

Proceedings of the Dice Throw Symposium, 21-23 June 1977

Vols. 2 and 3, General Electric Company-TEMPO, DASIAC, Santa Barbara, CA, July 1977

K0358

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Project Officers Report, Test Directorate, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, NM, April 1984

K0354

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K0355

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K0357

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Vol. I, Sessions 1, 2A, and 3A, General Electric Company-TEMPO, DASIAC, Santa Barbara, CA, 1 May 1973

K0094

Chest Wall Velocity as a Predictor of Nonauditory Blast Injury in a Complex Wave Environment

Axelsson, H., and Yelverton, J. T.

J. of Trauma: Injury, Infection, and Clinical Care, 40 (3): S31 to S37, 1996

K0115

The Non-Auditory Effects of Complex Blast Waves on Personnel Inside an APC Attacked by Shaped Charge Warheads

Axelsson, Hakan and Richmond, D. R.

Swedish Defence Research Establishment, FOA rapport, presented at the Sixth International Symposium on Wound Ballistics, 1-4 November 1988, Chongqing, People's Republic of China

K0002

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Betz, P.A., Bowen, I. G., Chiffelle, T. L., Damon, E.G., Fletcher, E.R., Gaylord, C.S., Hicks, W., Perret , R.F. et al.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, Albuquerque, NM, prepared for Defense Atomic Support Agency, Washington, D.C., 1 June 1965

K0020

Radiation Effects on Auditory and Visual Discrimination Tasks in Monkeys

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Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., March 1970

K0065

The Effects of Airblast on Discriminated Avoidance Behavior in Rhesus Monkeys

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K0347

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K0106

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Bowen, I. G., Fletcher, E. R., Richmond, D. R., Hirsch, F. G., and White, C. S.

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K0119

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Progress Report, Contract AT(29-1)-1242, Lovelace Foundation, Albuquerque, NM, prepared for U.S. Atomic Energy Commission, Division of Technical Information, Oak Ridge, Tenn, June 18, 1956

K0010

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K0078

Effects of 60Co on Electrical Self-Stimulation of the Brain and Blood Pressure

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K0173

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K0083

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Picture Memory (Pseudomatching) in the Rhesus Monkey

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K0036

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K0323

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K0145

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Damon, E. G.

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K0008

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The Effects of Shock-Tube-Generated Air Blast on Guinea Pigs Mounted in Model Foxholes of Various Design

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K0021

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Damon, E. G., Gaylord, C. S., Yelverton, J. T., and Richmond, D. R.

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Acute Effects of Air Blast on Pulmonary Function in Dogs and Sheep

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K0168

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K0182

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K0148

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K0153

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K0123

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K0081

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K0331

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K0047

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K0062

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Section II.

BOP Kirtland Database
Sorted Alphabetically by Title

BOP Kirtland Data Sorted Alphabetically by Title

K0096

A Chronically Implanted Arterial Catheter for Unanesthetized Animals

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Report to the Test Director, Lovelace Foundation for Medical Education and Research, Civil Effects Test Group, Atomic Energy Commission Technical Information Service, Oak Ridge, Tenn., Technical Services, Department of Commerce, Washington, D. C.

K0039

The Nature of the Problems Involved in Estimating the Immediate Casualties From Nuclear Explosions

White, C. S.

Technical Report, Lovelace Foundation for Medical Education & Res., U. S. Atomic Energy Commission, Div. of Technical Information, Oak Ridge, Tennessee, National Technical Information Service, U. S. Depart. of Commerce, Springfield, VA, July 1971

K0220

The Nature of the Problems Involved in Estimating the Immediate Casualties from Nuclear Explosions

White, C. S.

Lovelace Foundation for Med. Ed. & Res., summarized before The Conference on Disaster Medical Care, American Medical Association Committee on Disaster Medical Care/Council on National Security, Albuquerque, NM, November 15, 1968

K0115

The Non-Auditory Effects of Complex Blast Waves on Personnel Inside an APC Attacked by Shaped Charge Warheads

Axelsson, Hakan and Richmond, D. R.

Swedish Defence Research Establishment, FOA rapport, presented at the Sixth International Symposium on Wound Ballistics, 1-4 November 1988, Chongqing, People's Republic of China

K0017

The Overpressure-Duration Relationship and Lethality in Small Animals

Richmond, D.R., Goldizen, V. C., Clare, V. R. and White, C. S.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., September 10, 1962

K0299

The Physics of Decelerative Tumbling, Operation Plumbbob

Fletcher. E. R.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, July 1965

K0025

The Relation Between Eardrum Failure and Blast-Induced Pressure Variations

White, C. S., Bowen, I. G., and Richmond, D. R.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, August 1967

K0086

The Relationship Between Eardrum Failure and Blast-Induced Pressure Variations

White, C. S., Bowen, I. G., and Richmond, D.R.

Space Life Sciences 2: 158-205, 1970

K0069

The Relationship Between Fish Size and Their Response to Underwater Blast

Yelverton, J. T., Richmond, D. R., Hicks, W., Saunders, K., and Fletcher, E. R.

Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D. C., 18 June 1975

K0296

The Relationship Between Fish Size and Their Response to Underwater Blast

Yelverton, J.T. and Richmond, D. R.

Technical Paper, Lovelace Foundation for Medical Education and Research, presented at 2nd Conference on the Environmental Effects of Explosions and Explosions, Naval Surface Weapons Center, Silver Spring, MD, October 1976

K0159

The Relationship Between Selected Blast Wave Parameters and the Response of Mammals Exposed to Air Blast

Richmond, D. R., Damon, E. G., Fletcher, E. R., Bowen, I. G. and White, C.S.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, Nov 1966

K0085

The Relationship Between Selected Blast-Wave Parameters and the Response of Mammals Exposed to Air Blast

Richmond, D. R., Damon, E. G., Fletcher, E. R., Bowen, I. G., and White, C. S.

Ann.of the NY Acad. of Sciences, 152: 103-121, October 26, 1968

K0137

The Response of Dummies Inside a C3 Tactical Shelter on a CVCV Truck Exposed to Blast and Thermal on Event Misty Picture - U.S. Army Natick, Experiment 1015

Richmond, D.R.

Draft Report, Los Alamos National Laboratory, LS-1 KAFB Site, to American Development Corporation, North Charleston, SC, January 1988

K0082

The Scattering of Thermal Radiation Into Open Underground Shelters

Davis, T. P., Miller, N. D., Ely, T. S., Basso, J. A., and Pearse, H.E.

Technical Report, Civil Effects Exercise, Civil Effects Test Operations, U. S. Atomic Energy Commission, Office of Technical Services, Washington, DC, October 30, 1959

K0074

The Scope of Blast and Shock Biology and Problem Areas in Relating Physical and Biological Parameters

White, C. S.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, November 1966

K0051

The Thoraco-Abdominal System's Response to Underwater Blast

Fletcher, E. R., Yelverton, J. T., and Richmond, D. R.

Final Technical Report, 1 June 74 to 30 Sep 76, Lovelace Foundation for Medical Education and Research, prepared for Office of Naval Research, Arlington, VA, September 1976

K0073

The Tolerance of Birds to Airblast

Damon, E. G., Richmond, D. R., Fletcher, E. R., and Jones, R. K.

Final Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 23 July 1974

K0021

The Tolerance of Cattle to "Long"-Duration Reflected Pressures in a Shock Tube

Damon, E. G., Gaylord, C. S., Yelverton, J. T., and Richmond, D. R.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, August 1966

K0016

The Tolerance of Guinea Pigs to Air Blast When Mounted in Shallow, Deep, and Deep-With-Offset Chambers on a Shock Tube

Richmond, D.R., Clare, V. R., and White, C. S.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., October 27, 1962

K0033

Thermal Radiation Measurements (Parts I and II), Project 39.3: Operation Plumbbob

Greig, A. L., and Pearse, H. E.

Preliminary Report. Operation Plumbbob, Nevada Test Site, May-October 1957, Lovelce Foundation for Medical Education and Research, prepared for Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D. C., May 23, 1958

K0108

Threshold for Laryngeal Lesions from Repeated Blasts - A Progress Report

Richmond, D. R.

Progress Report, Lovelace Biomedical and Environmental Research Institute, prepared for Department of the Army, Walter Reed Army Institute of Research, Washington, D.C., June 23, 1980

K0344

Threshold Lung Injury in Goats from a 500-Ton Explosion, Program 4, Project 4.4, Suffield Experimental Station, Alberta, Canada - 1964

Richmond, D. R.

Preliminary Report, Lovelace Foundation, in Appendix J, Minutes of the 4th Meeting, Panel N1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, Toronto, Canada, 28-30 Sep 1964

K0235

Translation Effects Criteria

Bowen, I. G.

Illustrative material and notes, Lovelace Foundation for Medical Education and Research, presentation before Subcommittee on Blast and Thermal, Advisory Committee on Civil Defense, National Academy of Sciences, Washington, D. C., Aug 1967

K0345

Translation of Goats and Anthropomorphic Dummies by Blast Waves, Program 4, Project 4.5, Suffield Experimental Station, Alberta, Canada - 1964

Richmond, D. R.

Preliminary Report, Lovelace Foundation, in Appendix K, Minutes of the 4th Meeting, Panel N1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, Toronto, Canada, 28-30 Sep 1964

K0014

Translational Effects of Air Blast from High Explosives

Bowen, I.G., Woodworth, P. B., Franklin, M. E., and White, C. S.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, November 7, 1962

K0119

Translational Effects of Blast Waves: A review of past work and suggestions for future experiments with 500-ton high-explosive shot

Bowen, I. G., Richmond, D. R., and White, C. S.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., March 11, 1963

K0123

Translational Problems in Shelters

Fletcher, E. R.

Report, Minutes of Fifth Meeting, Panel N-1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, US Naval Radiological Defense Laboratory, San Francisco, CA and Lovelace Foundation, Albuquerque, NM, pp H-1 to H-21, May 10-14 1965

K0175

Trip Report on Fifth International Symposium on Military Applications of Blast Simulation and visit to Swedish Defense Institute

Richmond, D. R.

Trip Report on Fifth International Symposium on Military Applications of Blast Simulation, Stockholm, Sweden, May 23-26, 1977 Lovelace Foundation for Medical Education and Research, Director, AFRRI, Bethesda, MD, 26 July 1977

K0028

Tyrosine Aminotransferase Induction in Rat Liver as a Response to Irradiation and/or Flash Burn Injuries

Henderson, T. R. and Jones, R. K.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 30 October 1972

K0124

Underwater Blast Criteria

Bowen, I. G.

Letter of transmittal w/enclosure, Lovelace Foundation for Medical Education and Research, submitte to U. S. Naval Ordnance Laboratory, MD., August 1968

K0233

Underwater Blast Studies

Richmond, D.R.

Draft copy of presentation, Lovelace Biomedical and Environmental Research Institute, undated.

K0234

Underwater Blast Studies With Animals

Richmond, D. R., Yelverton, J. T., Gaylord, C. S., and Fletcher, E. R.

Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Explosions Research Department, US Naval Ordnance Laboratory, Silver Spring, MD, February 1970 (unclassified formerly Confidential)

K0347

Underwater Blast Swimmer Vulnerability

Bowen, I. G.

Correspondence, Lovelace Foundation for Medical Education and Research, submitted to U.S. Naval Ordnance Laboratory, Silver Spring, MD, September 1968.

K0109

Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals

Yelverton, J. T

Lovelace Biomedical and Environmental Research Institute, presented at The 102nd Meeting of the Acoustical Society of America, Carillon Hotel, 30-Nov-4 Dec 1981, Miami Beach, FL, 1981

K0295

Underwater Explosion Levels Evaluated by a Swimmer

Richmond, D. R.

Technical Paper, Lovelace Foundation for Medical Education and Research, presented at 2nd Conference on the Environmental Effects of Explosions and Explosions, Naval Surface Weapons Center, Silver Spring, MD, October 1976

K0165

Underwater Shock Facility and Explosion Levels Evaluated by a Swimmer

Richmond, D. R.

Technical Paper, Contibution 4:2, pp 4:2:1-4:2:20, Lovelace Biomedical and Environmental Research Institute, presented at the 5th International Symposium on Military Application of Blast Simulation, Stockholm, Sweden, 23-26 May 1977

K0290

Vulnerability of Protective Structures Subjected to Fuel-Air-Explosive Weapon Attack

Jennsen, A.

Final Report, Special Study Group of Experts, prepared for the Norwegian Defense Construction Service, Oslo, Norway, June 1988

K0170

Whole-Body Impact Studies With Sheep

Richmond, D. R.

Presentation, Lovelace Biomedical and Environmental Research, DCPA Meeting, Asilomar, CA, April 21-25, 1974

Section III.

BOP Kirtland Database
Sorted Numerically by ID Number
(Abstracts Included)

BOP Kirtland Data Sorted Numerically with Abstracts

K0001 DASA-1859

AUTHOR Fletcher, E. R. and Bowen, I. G.

TITLE Blast Induced Translational Effects

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, Albuquerque, NM prepared for Defense Atomic Support Agency, Washington, D.C., November 1966

ABSTRACT A mathematical model was developed to predict the time displacement histories of objects translated by the blast winds from conventional or nuclear explosions; these predictions were then compared to actual experiments. The objects studied varied in size from 139 mg spheres to man and were all assumed to be free to move over a smooth horizontal surface. The effects of ground friction* could either be included or neglected, but when they were considered the ground friction eventually brought the objects to rest after the winds had passed. The values of ground friction used were determined experimentally and were found to be functions of the velocity and mass of the object being displaced.

The translational model was general enough for either classical or nonclassical blast waves to be considered. Results for a chemical explosion were obtained by using both the computed blast waves of various authors and the experimentally determined blast waves. These predicted results were compared with each other as well as with experimental data obtained with steel spheres. The model was used to determine dynamic pressure impulses necessary to explain the measured sphere velocities at three ranges from ground zero.

Another mathematical model was briefly described which was developed to compute the detailed two-dimensional trajectories of objects as they roll, slide and bounce along the ground. The model closely predicted the measured distances between bounces and the total displacements of concrete blocks and large stones and thus helped to explain the mechanisms of tumbling by which an irregular object may become airborne during both the accelerative and the decelerative phases of displacement.

*Ground friction is used here to designate the process of energy dissipation by sliding, rolling, and impacting along the ground.

AUTHOR Betz, P.A., Bowen, I. G., Chiffelle, T. L., Damon, E.G., Fletcher, E.R., Gaylord, C.S., Hicks, W., Perret , R.F. et al.

TITLE Biomedical Program 500 Ton Explosion

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, Albuquerque, NM, prepared for Defense Atomic Support Agency, Washington, D.C., 1 June 1965

ABSTRACT Six blast projects, four dealing with the effects of overpressure on goats or cattle and two involving translational effects of pressure and wind, were carried out in conjunction with the detonation of 500 tons of high explosive at the Suffield Experimental Station located in Canada near Ralston, Alberta.

Of 35 goats, placed 5 each at 7 stations ranging from about 30 to almost 60 psi and exposed side on to the blast wave in front of stout wire screens to avoid or minimize translational hazards, all animals but one at 30 psi were lethally injured. The immediate cause of death, obscured by the occurrence of greater than expected ejected from the crater and probably influence in most cases by both overpressure and the impact of nonpenetrating debris, could not be determined with certainty. That either challenge along might have been lethal in a high percentage of cases is considered a likely possibility. Such remarks also apply to 24 mortally injured cattle, all exposed in a similar geometry, 4 each at 6 stations spanning a range in overpressure from 40 to 65 psi.

Among 18 goats, 6 each located at the 30, 35 and 40 psi stations in 2 types of foxholes, one a rectangular trench 7x2x6 ft long and the other similar except for a 2x2x6 ft long offset placed 2 ft above the floor, 16 suffered only minor injuries, but 2 were killed by ejecta. Even though the maximal pressures measured inside the foxholes ranged from approximately 37 to 67 psi, being mostly higher than the free field overpressures, an alteration in the shape of the rising portion of the wave occurred which made the pulse less effective biologically.

Goats, 20 in number and also exposed in front of screens side on to the blast wave at the 10 and 15 psi lines, were examined post shot to help determine the overpressure associated with minimal lesions of the lungs. Except in 4 animals injured by debris ejected from the crater, 2 lethally, mean lung weights did not differ significantly from controls. The data indicated that 10 psi was near the threshold value for tiny petechial hemorrhages and for slight emphysematous lesions detected micropscopically. The functional changes of the latter were not studied and their possible importance yet remains to be determined.

Eardrum failure among the goats ranged from 55 per cent at 10 psi and 68 percent at 15 psi, to over 80 per cent at the higher overpressures. In the case of the latter, fractures and abdominal lesions were also common in cases struck by falling debris lofted from the crater area.

Translational velocities determined photographically at the 10 and 15 psi stations were 30.1 and 33.9 ft/sec, respectively, for 65 lb anthropometric dummies exposed standing face on, 27.2 ft /sec and 31.1 ft/sec, respectively, for goat cadavers exposed side-on to the blast wave. Displacements of the standing dummies were 59.8 ft radially and 20.9 left at 15 psi and 75.4 ft downwind and 1.9 ft to the right at 30 psi. The dummies exposed prone and head on to the blast wave moved 1.3 ft downwind and 3.5 ft to the left at 10 psi, 0.7 ft radially and 0.3 ft to the left at 15 psi, and 10.9 ft radially and 0.8 ft to the right at 30 psi. The goat displacements were radially 50.6 ft (20.8 ft left), 17.9 ft (9.0 ft left) and 80.2 ft (4.4 ft left) at the 10, 15, and 30 psi stations, respectively. Thus, both the dummy and goat data evidence the occurrence of anomalous wind patterns at the 10 psi station, but this was not so at 30 psi and questionable at the 15 psi lines.

Time-of-arrival figures, determined photographically and by calculation, for debris allowed the minimum velocities for crater ejecta to be estimated. These were 176, 159, and 137 ft/sec at the 10, 15 and 30 psi stations, respectively. Impact velocities of various sized steel spheres were determined at 10, 15 and 30 psi locations. Using the data obtained and appropriate acceleration coefficients, the dynamic pressure impulses and the peak blast wind velocities were estimated. Agreement with theory proved reasonably good. Also the sphere data were used to predict displacement velocities for anthropometric dummies and goats. Those predicted were within 10 percent of those actually measured photographically as noted above.

K0003 DASA-1312

AUTHOR Clare, V.R., Richmond, D. R., Goldizen, V. C., Fischer, C. C., Pratt, D. E., Gaylord, C. E. and White, C. S.

TITLE The Effects of Shock Tube Generated, Step-Rising Overpressures on Guinea Pigs Located in Shallow Chambers Oriented Side-On and End-On to the Incident Shock

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, Albuquerque, NM, prepared for Defense Atomic Support Agency, Washington, D.C., May 31, 1962

ABSTRACT A total of 308 guinea pigs were exposed to air blast in four close-fitting, shallow, rectangular chambers mounted on the top, bottom and sides of an air-driven shock tube. With a reflecting plate at the downstream edge of the chambers, the animals were exposed to "long" -duration, shock overpressures that initially rose in a single step. The LD50--24-hr reflected pressure calculated from grouping all positions was 36.2 + 0.8 psi.

By moving the reflecting plate to various distances downstream of the chambers, shock overpressures that initially rose in two steps were applied. The results were that the animals' tolerance to overpressures rose as the time between pressure steps was increased.

Comparison of the LD 50's obtained with animals in each chamber revealed that there was not a significant statistical difference in their tolerances, whether they were "loaded" initially with the single-step pulse from their right, left, dorsal or ventral surfaces.

Animals that survived pressure-time conditions in the lethal range were considered as having been injured by the blast, and were all pooled for 30-day serial sacrifice. It was found that the lung hemorrhage "cleaned up," and the lung weights returned to normal in 7 to 10 days as did the submucosal hemorrhages in the stomach and intestines. The body-weight curve displayed an initial drop in 2 to 3 days, after which it rose to the starting level by the sixth day and then paralleled the controls.

K0004 DASA-1271

AUTHOR White, C. S.

TITLE Biological Effects of Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D. C., December 1961

ABSTRACT The current state for knowledge relevant to biological blast effects was summarized in a selective manner. Initially, five problems of concern to those who would relate the environmental variations produced by nuclear weapons with biological response and hazard assessment were pointed out. Primary, secondary, tertiary, and miscellaneous blast effects were defined and selected interspecies experimental data of a physical and pathophysiological nature useful in estimating human response were presented. Tentative biological criteria defining "safe" levels of exposure were set forth as were survival curves for different conditions for exposure in Hiroshima. These were discussed along with the comparative variations in range of the "free-field" effects as they vary with explosive yield. The fundamental requirement for surviving seconds , minutes, and hours to abet survival for days, weeks, months, and years was emphasized along with the necessity for planning protective measures against all hazardous weapons effects as one attractive alternative for minimizing casualties and maximizing survival in the event of a nuclear war.

K0005 DASA-1246

AUTHOR Richmond, D. R., Clare, V. R., Goldizen, V. C., Pratt, D. E., Sanchez, R. T., and White, C.S.

TITLE A Shock Tube Utilized to Produce Sharp-Rising Overpressures of 400 Milliseconds Duration and Its Employment in Biomedical Experimentation

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, April 7, 1961

ABSTRACT A shock tube employed for blast biology studies is described along with the results of one series of experiments. The shock tube is air-driven and utilizes Mylar plastic diaphragms. The compression chamber is 17.5 ft. in length and 40.5 in. I.D.; it reduces in diameter to 23.5 in. over a 3-ft-long transition section just upstream of the diaphragm station. The expansion chamber consists of 30 ft.. Of 23.5 in. I.D. tubing followed by 22 ft. of 40.5 in. I.D. tubing. It is closed distally by a steel end-plate to generate high pressures from the reflected shock. Three vents in expansion side of the system serve to control the duration of the overpressure and to eliminate multiple reflections by bleeding off the reflected shock as it travels upstream.
An interspecies correlation is presented based on mortality data from six species of experimental animals with an extrapolation to a 70 kg animal.

K0006 DNA-3081T

AUTHOR Richmond, D. R., Yelverton, J. T., and Fletcher, E. R.

TITLE Far-Field Underwater-Blast Injuries Produced by Small Charges

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 1 July 1973

ABSTRACT Underwater-blast injuries, at increasing ranges beyond the lethal zone from small charges, were studied using animals. The study was conducted in an artificial pond that measured 220 by 150 ft. at its surface. The pond was 30 ft. deep over its 30- by 100-ft center portion. Sheep, dogs, and a few monkeys were exposed to the blast oriented vertically in the water (long axis perpendicular to the surface). Most were exposed to the blast at 1-ft depths, heads above the surface, and a limited number at 2- and 10-ft depths. Explosive charges were mostly bare spheres of Pentolite weighing 0.5, 1, 3, and 8 lb. All charges were detonated at 10-ft depths. The immersion-blast injuries were of minor severity and consisted mainly of lung hemorrhages and small areas of contusions in the gastrointestinal tract. The incidence and severity of the injuries were correlated with the impulse in the underwater blast wave. Tests were run with dogs beneath the surface to evaluate eardrum rupture. The subjects were right-side-on to the blast, and a probit analysis run on the data for the right years yield an impalas of 22.6 psi.msec for 50-percent eardrum rupture. Based on the results of this study, a safe impulse level of 2 to 3 psi.msec for unprotected swimmers, head above the surface, was proposed. This safe impulse level was discussed in relation to the underwater blast-wave parameters in the test pond and existing response data for personnel.

K0007 DASA-1853

AUTHOR Richmond, D.R., Gaylord, C. S., Damon, E. G., and Taborelli, R. V.

TITLE DASA-AEC-Lovelace Foundation Blast-Simulation Facility

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., August 1966

ABSTRACT The DASA-AEC-Lovelace Foundation Blast-Simulation Facility for the biomedical investigation of the effects of blast and shock is described in detail. Photographs, descriptions, and specifications of four air-driven shock tubes, ranging from 12 to 72 inches in diameter, and a concrete pad, high-explosive test site are given. The instrumentation system and shock-tube and gauge-calibration procedures are included. Test parameters for each shock tube are briefly summarized and supported by typical pressure-time patterns and calibration curves.

K0008 DASA 1852

AUTHOR Damon, E. G., Gaylord, C. S., Hicks, W., Yelverton, J. T., Richmond, D. R., and White, C. S.

TITLE The Effects of Ambient Pressure on the Tolerance of Mammals to Air Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, August 1966

ABSTRACT Seventy-six dogs, 43 goats, 211 rats and 255 guinea pigs were exposed to reflected shock pressure at ambient pressures ranging from 5 to 42 psia in air-driven shock tubes. Animal tolerance, expressed as LD50-one-hour overpressures rose progressively as the ambient pressure was increased.
By analysis of the results of this study, combined with those from previous shock-tube investigations, a general equation for the regression of LD50 pressure on ambient pressure for mammals was derived. From this equation and previous estimates of the LD50 pressure for man's tolerance to overpressures of 400-msec duration at an ambient pressure of 12 psia, an equation relating LD50 pressure to ambient pressure was developed for the 70-kg mammal.

K0009 DASA-1777

AUTHOR Richmond, D. R. and C. S. White

TITLE Biological Effects of Blast and Shock

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, April 1966

ABSTRACT The scope of blast and shock biology was set forth covering effects resulting from overpressure (primary), flying debris (secondary), and displacement (tertiary). Procedures employed in the laboratory for simulating the blast wave forms as they varied within structures on nuclear tests were described.
For each effect, a selected summary of current information relating the physical parameters to given levels of biological response was presented. From this, the blast and shock hazards estimated for personnel, as a function of range and yield, were illustrated in the form of curves.
The range-yield-effects relationship for the biological criteria was discussed in terms of free-field and other exposure situations. They were compared with similar range-effects data for thermal and nuclear radiation.

K0010 DASA-1675

AUTHOR Bowen, I.G., Holladay, A., Fletcher, E. R., Richmond, D. R., and White, C. S.

TITLE A Fluid-Mechanical Model of the Thoraco-Abdominal System With Applications to Blast Biology

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., June 14, 1965

ABSTRACT A mathematical model was described which was developed to compute some of the fluid-mechanical response of the thoraco-abdominal system subjected to rapid changes in environmental pressure. The approach -- helpful in understanding many of the primary effects of air blast on animals, but applicable to related problems involving rapid changes in environmental pressure as well -- incorporated an air cavity representing the gaseous volume of the lungs (although it is recognized that gas in the organs of the abdomen may influence the response of the system), two movable pistons and an orifice through which gas might pass in either direction. One of the pistons represented the chest wall and the other that portion of the abdomen which moves with the diaphragm to change the lung volume. Each piston was "assigned" an effective mass and area, a spring constant, and a damping factor. The orifice was taken to "incorporate" the characteristics of the many airways of the respiratory system. Parameters relating the animal to the model were estimated, tested and then adjusted as required by comparing model results with experimental records of thoracic pressures recorded for rabbits exposed to blast waves in shock tubes.

Equations were derived to scale parameters applicable to a given animal those for similar creatures of arbitrary mass. By dimensional analysis other equations were developed to relate, for a given biological response, the body mass of similar animals to blast wave parameters. Numerical solutions of the model were presented to help explain the mechanisms involved when animals were "loaded" with typical wave forms or with pulses increasing to a maximum in a stepwise manner, a contingency associated with a quite significant increase in mammalian tolerance to over-pressure. Differences in response to "short-" and "long"-duration blast waves were noted. Applications of the scaling concepts were exemplified in several ways making use of the published data in blast biology. In one instance, the blast tolerance of a 70-kg mammal was estimated for sea-level ambient pressure making use of experimental data for dogs and goats obtained at Albuquerque altitude (ambient pressure of 12 psia). That the latter might have significant implications in assessing human response to blast-produced overpressures was discussed along with several other relevant matters.

K0011 DASA-1242

AUTHOR Richmond, D.R., Goldizen, V. C., Clare, V. R., Pratt, D. R., Sherping, F., Sanchez, R.T., Fischer, C.C., and White, C.S.

TITLE Mortality in Small Animals Exposed in a Shock Tube To "Sharp"-Rising Overpressures of 3-4 msec Duration

SOURCE Technical Progress Report, Defense Atomic Support Agency, Washington, D.C., June 15, 1961

ABSTRACT A total of 661 animals were exposed to "sharp"-rising overpressures of 3-4 msec duration using a shock tube of novel design which produced a pressure pulse similar to that obtained with high explosives. The reflected shock overpressure associated with 50 per cent lethality were 29.0, 38.6, 35.2 and 35.6 for the mouse, rat, guinea pig and rabbit, respectively. Other observations included the time of death in mortally wounded animals and gross pathological lesions likely to contribute to mortality. Selected data from the literature bearing upon the influence of overpressure and pulse duration on lethality were reviewed. These included pulse durations ranging from less than 1 msec to 6-8 sec. The critical pulse duration, that duration shorter than which the overpressures required for mortality increases sharply, was noted to depend upon animal size and to be of the order of many hundreds of microseconds to very few milliseconds for "smaller" animals and a few to many tens of milliseconds for "larger" animals.

K0012 DASA-1483

AUTHOR Damon, E.G., Richmond, D. R., and White, C. S.

TITLE The Effects of Ambient Pressure on the Tolerance of Mice to Air Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., March 1964

ABSTRACT Mice were exposed to overpressures of "long" duration in the expansion chamber of an air-driven shock tube inside which the initial, preblast pressures were varied over sixfold. When the animals were held at the initial pressure for one hour following the blast before being returned to the ambient pressure of the laboratory, tolerance values, expressed as LD50-1-hour gauge pressures, increased fourfold; they were 20.3, 31.0, 44.5, 55.4, and 91.8 psi for initial pressures of 7, 12, 18, 24, and 42 psia, respectively. When animals were returned to ambient level soon after blast exposure, the LD50 pressures were lower than the initial pressures lower than ambient. The feasibility of scaling biological blast effects as a function of altitude was discussed and one approach suggested by available empirical data was regarded as promising, but tentative procedure.

K0013 DASA-1462

AUTHOR White, C. S.

TITLE Tentative Biological Criteria for Assessing Potential Hazards from Nuclear Explosions

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., December 1963

ABSTRACT Available, but tentative and incomplete biological criteria of use in assessing human hazards from nuclear explosives were presented along with the source of data from which they were derived. The criteria were related to effects parameters employing free-field, some "geometric," and translational scaling to the end that areas at potential risk from nuclear detonations ranging in yield from 1 kt to 100 Mt could be estimated. The problem areas involved and many of the uncertainties due to lack of both physical and biological data as well as to the fact that the conditions of exposure represent a major factor in determining the environmental variations that challenge man and hence in controlling the incidence of casualties as well as survival were noted and briefly discussed. The utility of the range-yield-effects relationships set forth was emphasized as was the need for a continued collaborative effort between biologically and physically oriented personnel to improve understanding biological response on the one hand and basic effects phenomenology on the other.

K0014 DASA-1336

AUTHOR Bowen, I.G., Woodworth, P. B., Franklin, M. E., and White, C. S.

TITLE Translational Effects of Air Blast from High Explosives

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, November 7, 1962

ABSTRACT Introduction and Summary: A portion of the studies of the biological effects of blast from nuclear explosions has been concerned with the translational effects of blast waves for objects as small as a 10-mg stone and as large as a 168-lb man. Computed results from theoretical studies when compared to field data for near--ideal blast waves from nuclear explosions have demonstrated that the motion of experimental objects can be satisfactorily predicted for free-field conditions or for window glass in houses.

This report presents for high explosives (free-air burst) the results of a similar theoretical study--specifically, computed velocity, displacement, and acceleration as functions of time for a variety of objects exposed to blast waves with 13 maximum overpressures ranging from 1 to 20 atm. Although all computations were made for 1 ton of high explosives burst in free air, the results may be easily scaled to lower or higher yields and to surface bursts. The translated objects, or missiles, are identified in this study by their acceleration coefficients which range from 0.01 to 6.0 ft2/lb.

K0015 DASA-1335

AUTHOR Richmond, D.R., and White, C. S.

TITLE A Tentative Estimation of Man's Tolerance to Overpressures from Air Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, Defense Atomic Support Agency, Washington, D.C., November 7, 1962

ABSTRACT Tentative estimates of the "sharp"-rising overpressures as a function of duration which represent a lethal hazard to the 70-kg animal 1, 50 and 99 percent of the time were presented. The predictions were based on interspecies correlations and extrapolations encompassing blast-tolerance data for six mammalian species. The tentative application of the data to indicate human blast tolerance was discussed and relevant uncertainties in the estimates were emphasized. It was also pointed out that biologic tolerance would be different for air-blast pulses having non-ideal wave forms frequently associated with various geometries of exposure.
Selected pathophysiological information pertinent to the biological response following blast exposure was given; namely, survival time and selected postshot observations of dogs and goats.

K0016 DASA-1334

AUTHOR Richmond, D.R., Clare, V. R., and White, C. S.

TITLE The Tolerance of Guinea Pigs to Air Blast When Mounted in Shallow, Deep, and Deep-With-Offset Chambers on a Shock Tube

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., October 27, 1962

ABSTRACT One hundred and eighteen guinea pigs were exposed to air blast in shallow, deep, and deep-with-offset chambers mounted on a shock tube. The LD50-24 hours, in terms of the incident shock pressures measured adjacent to the chambers, was calculated by probit analysis to be 34.9 psi, 19.5 psi, and 26.8 psi for animals in threshold, deep, and deep-with-offset chambers, respectively. According to the LD50 incident pressures, the shallow chambers offered the most protection against air blast; the deep chambers, the least.
Comparing the LD50-pressure "dose" at the animals' location revealed little difference in their tolerance to overpressure, per se; i.e., LD50 reflected pressures measured by gauges within the deep and deep-with-offset chambers were 34.6 and 35.9 psi, respectively. The LD50 incident shock pressure of 34.9 psi in the shallow chambers was considered to be the "dose" at the animal's location in that instance.
The protection against blast provided by the three chambers and the response of animals to the particular pressure-time patterns encountered are discussed.

K0017 DASA-1325

AUTHOR Richmond, D.R., Goldizen, V. C., Clare, V. R. and White, C. S.

TITLE The Overpressure-Duration Relationship and Lethality in Small Animals

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., September 10, 1962

ABSTRACT A total of 993 mice, rats, guinea pigs and rabbits were exposed to sharp-rising overpressures of various short durations. The were mounted on a concrete pad above which high-explosive charges, ranging in weight from 0.50 oz. to 64 lb. were detonated.
Pressure-time measurements were obtained with pencil-type and shock-tube piezo-electric gauges on the pad directly beneath the charges. The duration of the blast waves ranged from 0.40 msec to 6.8 msec. The LD50 pressures were calculated for each species at the different pulse durations.
In general, the pressures required to produce 50-percent lethality rose at the shorter durations. Combining the results of this study with those from previous shock-tube investigations made it possible to define the tolerance of four small-animal species to sharply rising overpressures as a function of pulse duration.

K0018 DASA-1313

AUTHOR Richmond, D.R.

TITLE The Exposure of Guinea Pigs to Pressure-Pulses Generated During the End-to-End Test (No. 2) of Atlas Missile 8-D (March 31, 1962)

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, June 26, 1962

ABSTRACT To help determine the extent of the blast hazard to the operator of a Pressure Control Unit, an Atlas 8-D missile was pressurized to 35 psi with gaseous nitrogen and ruptured with an explosive charge. Three guinea pigs were placed on the Pressure Control Unit which was located beneath the ramp 90 ft from the missile. In addition, ten guinea pigs were placed on the surface of the simulated ramp at 30-, 35-, 75-, and 94 ft ranges.
Following the burst, missile fragments littered the test area, although none were found at the Pressure Control Unit. Overpressures of only 0.3 psi were recorded in the vicinity of the Pressure Control Unit. The pressure pulse was slow rising (9-14 msec) and endured for about 25 msec. The three guinea pigs at that location were unharmed.
At the 30-ft ranges, pressures of 1.1-1.4 psi were recorded with times to peak and durations of 2-3 msec and 13-16 msec, respectively. One guinea pig's eardrum was ruptured and one animal sustained a slight degree of lung hemorrhage. The other eight animals were unhurt. The biological results were discussed in relation to the pressure-time data.

K0019 DNA-5618T

AUTHOR Richmond, D.R., Fletcher, E. R., Saunders, K., and Yelverton, J. T.

TITLE Injuries Produced by the Propagation of Airblast Waves Through Orifices

SOURCE Topical Report for Period 1 March 1979-1 March 1980, Lovelace Foundation for Medical Education and Research, Defense Atomic Support Agency, Washington, DC, 1 March 1980

ABSTRACT The biological effects produced by airblast waves passing through small openings were evaluated using sheep. Specimens were oriented with their thoraces in front of circular orifices of 3.8- and 7.6-cm radii in the endplate of a 0.6 m diameter shocktube. Subjects were also tested in front of a D-shaped orifice, equivalent radius of 24 cm, in the upstream wall of a test chamber located beyond the end of a 1.m diameter shocktube. The animals sustained crushing type of injuries, primarily to the rib cage, lungs, and liver.
Stagnation overpressures were measured at various distances downstream from circular and rectangular orifices. Equations were developed to compute the stagnation overpressures as a function of input overpressures.
Injury levels were related to the stagnation overpressure and distance from the orifice. Based on these results, injury criteria were developed for personnel: no injury below 0.7, slight injury from 0.7 to 1.4, and severe injury above 1.4 atm of stagnation overpressure. The criteria were discussed in relation to the occupants of armored vehicles.

K0020 DASA-2460

AUTHOR Bogo, V., Hutton, R. A., and Bruner, A.

TITLE Radiation Effects on Auditory and Visual Discrimination Tasks in Monkeys

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., March 1970

ABSTRACT Following shock-avoidance training on color and auditory discrimination problems, 12 rhesus monkeys were exposed to either 1500 or 6000 rads of pulsed, neuron-gamma radiation. Testing began one hour after irradiation. All monkeys exhibited performance decrement in the form of generalized incapacitation shortly before death, which occurred earlier for the 6000 rad animals. Prior to onset of the moribund state, however, no significant changes in performance were observed, although marked fluctuations in individual performances were evident. Of the response measures used, response latency under went more change following irradiation than discrimination accuracy.

K0021 DASA-1855

AUTHOR Damon, E. G., Gaylord, C. S., Yelverton, J. T., and Richmond, D. R.

TITLE The Tolerance of Cattle to "Long"-Duration Reflected Pressures in a Shock Tube

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, August 1966

ABSTRACT Twenty-seven steers, mounted side-on against the endplate of an air-driven shock tube, were exposed to "sharp"-rising reflected pressures of 184-msec duration. Pressure-time measurements were made with piezoelectric pressure transducers. Autopsies were performed on all animals and the nature of their blast injuries determined.
The LD50 reflected pressure, obtained by probit analysis, was 43.1 psi for steers having a mean body weight of 180 kg. The results are compared with tolerance values obtained in previous investigations involving exposure of eight species of smaller animals to overpressures of 400-msec duration. Twenty-four hour, time-lethality data for steers are compared with those of five species of smaller animals.
The potential use of blast-injured domestic animals, as a source of food, is briefly discussed.

K0022 DNA-4045T

AUTHOR Bruner, A.

TITLE Immediate Changes in Estimated Cardiac Output and Vascular Resistance After 60Co Exposure in Monkeys

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 8 August 1976

ABSTRACT Aortic blood flow velocity, blood pressure, and heart rate were recorded in 12 unanesthetized, nonperforming monkeys during exposure to 1000 rad 60Co at 129-164 rad/min. The first post-radiation changes were seen within 3-4 min of the exposure's start and included tachycardia, a transient hypotension secondary to a loss in peripheral resistance, and a brief increase followed by a decrease to subnormal levels in cardiac output. Lowest cardiac output occurred between 10-20 min postexposure while blood pressure and peripheral resistance were recovering. It was proposed that the concurrent combination of low cardiac output, low blood pressure and supranormal peripheral resistance might sufficiently attenuate cerebral perfusion temporarily to account for the transient behavioral decrements often seen during this time. Histamine release was postulated as responsible for this vascular shock syndrome.

K0023 AFSWC-TN-61-8

AUTHOR Howarth, J. L. and Mills, R. O.

TITLE The Analysis of Urine Specimens for Uranium and Plutonium

SOURCE Technical Report, Headquarters, Air Force Special Weapons Center, Air Research and Development Command, Kirtland Air Force Base, NM, 1 Nov 1960

ABSTRACT Methods of analysis of urine for plutonium and uranium have been studied for the purpose of recommending the most suitable methods of analysis of these materials in persons exposed in peace time nuclear accidents. The sensitivity limits set for this purpose were 10 dpm per liter of urine for natural uranium.
Liquid scintillation counting techniques were found unsatisfactory, and elecrodeposition-autoradiography techniques, while providing much more than the required sensitivity, are unnecessarily complex. Alpha proportional counting in a flow counter is recommended.
The recommended extraction procedures are the bismuth phosphate-lanthanum fluoride coprecipitation technique for plutonium, and either the di-n-butyl orthophosphoric acid (DBP) extraction procedure or an anion exchange procedure for uranium.

K0024 DASA-2461

AUTHOR Damon, E.G., Yelverton, J. T., Luft, U. C., Mitchell, K., Jr., and Jones, R. K.

TITLE The Acute Effects of Air Blast on Pulmonary Function in Dogs and Sheep

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, March 1970

ABSTRACT Pulmonary function tests were conducted before and after exposure of animals to air blasts produced in shock tubes or by high explosives. Pressure-time measurements were made with piezoelectric pressure transducers during each air-blast exposure. Blood samples were obtained without anesthesia from an indwelling arterial catheter. The blood PO2, PCO2, and pH and the end-tidal and mixed expired CO2, O2, and N2 gas concentrations were measured for subjects breathing air and oxygen. There were increases in the alveolar-arterial O2 differences (A-a)O2, and venous admixture (Qs/Q) which generally correlated with the extent of blast-induced lung damage. Calculations indicated that most of the increase in (A-a)O2 for subjects breathing air could be attributed to the increase in Qs/Q alone. The threshold for lung injury resulting in increased venous admixture in sheep was about 20 psi for reflected overpressures of "long" duration. Pressures above 43 psi usually caused severe lung damage in which the venous-arterial shunt exceeded 30 percent of the cardiac output, a condition in which the arterial oxygen tension was below the level required for full saturation of the hemoglobin even with animals breathing pure oxygen.

K0025 DASA-2064

AUTHOR White, C. S., Bowen, I. G., and Richmond, D. R.

TITLE The Relation Between Eardrum Failure and Blast-Induced Pressure Variations

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, August 1967

ABSTRACT In field and laboratory experiments designed to study overall blast effects, incidental observations were made of the ears of over 490 animals. Those inside structures were exposed to a variety of "atypical" blast waves. Those located inside structures or in the open when high explosives were detonated were exposed to fairly "typical" wave forms. An attempt was made to relate the incidence of eardrum rupture to various elements of the measured pressure-time curves. The association was not the same for "typical" and "atypical" wave forms Within the limits of the meager data available, the quantitative differences were noted and discussed with emphasis on the apparent wide variability in tolerance for which an explanation was proposed.

K0026 DASA-2580

AUTHOR Damon, E.G., Yelverton, J. T., Luft, U. C., and Jones, R. K.

TITLE Recovery of the Respiratory System Following Blast Injury

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., October 1970

ABSTRACT The pattern of recovery of the respiratory system from blast injury was investigated in sheep exposed to overpressures in a shock tube. Measurements of the pH and blood gas tensions, determinations of the venous-admixture (Qs/Q) the alveolar-arterial oxygen gradient (A-a)O2 were conducted before and at intervals up to 132 days following injury. There was an immediate marked increase in Qs/Q, reduction in PaO2, and a moderate increase in (A-a)O2, with very little change in the pH or PCO2 of the arterial blood. The greatest recovery was evident within 24 hours with further gradual improvement seen 2, 7, 14, and 21 days after exposure. After the 21st day, most of the animals exhibited virtual complete recovery of the functional efficiency of the pulmonary system as tested at rest.

K0027 DASA-2630

AUTHOR Yelverton, J.T., Damon, E. G., Jones, R. K., Chiffelle, T. L., and Luft, U. C.

TITLE Effects of Irradiation and Blast on Pulmonary Function in Sheep

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D. C., January 1971 (unpublished)

ABSTRACT The changes in pulmonary function that result following unilateral exposure to LD50 doses of neutron-gamma irradiation and/or sublethal blast overpressures were investigated in sheep. Animals exposed to blast-only and radiation-plus-blast demonstrated large increments in venous admixture (Qs/Q) on the day of insult followed by a major recovery toward baseline values during the first 24 hours following injury. The venous admixture of the blast only animals approached baseline 7 days after exposure but that of the radiation-plus-blast sheep did not return to baseline until 21 days. The sheep exposed to radiation-only, blast-only, and radiation-plus-blast sustained similar reductions in mean carbon monoxide diffusing capacity (DLCO) which were below that of the control mean at 2 days and 7 days post exposure. All of the radiation-only and radiation-plus-blast sheep that survived to or beyond 21 days displayed an overshoot or recovery to their individual baseline DLCO values. The blast-only and radiation-plus-blast animals also exhibited an increased mean ineffective alveolar ventilation (VAIneff) which persisted from 1 to 14 days following the onset of trauma. The radiation-only sheep had an increased VAIneff from 2 through 7 days post exposure.

K0028 DNA-3001T

AUTHOR Henderson, T. R. and Jones, R. K.

TITLE Tyrosine Aminotransferase Induction in Rat Liver as a Response to Irradiation and/or Flash Burn Injuries

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 30 October 1972

ABSTRACT Tyrosine aminotransferase (TAT) activity was measured in rat liver to determine the extent to which thermal and/or irradiation injury resulted in induction of TAT synthesis and to determine the relationship between the severity of injury and the extent of TAT induction.
Flash burns elicited increased TAT activity in the liver, and the extent of induction was related to the severity of burn injury. Thermal injuries to the skin alone resulted in a detectable increase in TAT activity in about 30 percent of the animals, while deeper burns resulted in a uniform induction in all animals. The highest TAT activity occurred in the livers of animals just prior to death from thermal injuries.
Irradiation alone did not lead to a detectable increase in TAT activity but resulted in a "superinduction" effect in animals exposed to skin burns. The latter was considered to result from interference with repressor formation due to genetic damage, resulting in uncontrolled TAT synthesis.
Thus it appears that one of the events associated with the exaggerated catabolism of proteins following severe burns is the induction of enzyme synthesis in the liver. The manner by which excessive synthesis of enzymes such as TAT in the liver can contribute toward a poor prognosis is discussed.

K0029 DNA-3780T

AUTHOR Bruner, A., Bogo, V., and Gallegos, A. N.

TITLE Picture Memory (Pseudomatching) in the Rhesus Monkey

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D. C., 15 October 1975

ABSTRACT Pseudomatching, the selection of the correct comparison stimulus without dependence on presentation of a sample stimulus, was demonstrated in monkeys being trained on a shock-avoidance, matching-to-sample task.
Pseudomatching occurred whenever the problem sets were not fully counterbalanced for key position and correct symbol and seemed to represent memorization of specific stimulus configurations. Some animals showed the capacity to memorize hundreds of a different 4-choice problems as revealed by test trials on which the samples were omitted.

K0030 DNA-3161T

AUTHOR Bruner, A., Neely, A. W., Henderson, E. A., and Weiss, G. K.

TITLE Baroreceptor Reflex Response to Phenylephrine and Carotid Occlusion in Monkeys Receiving 1000 Rads Cobalt-60

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 10 August 1973

ABSTRACT Nine conscious monkeys received phenylephrine and carotid occlusion tests of baroreflex function before and after 1000 rads Cobalt-60 exposure (dose rate = 170 rads/min). During the early postradiation minutes, concomitantly with hypotension and tachycardia, both baroreflex tests revealed depressed sensitivity (diminishesd blood pressure and heart rate changes). After 8-15 minutes postradiation, the phenylephrine, but not the occlusion test, demonstrated a reversal to significant baroreceptor hypersensitivity which persisted 24 hours or more. No failure of the baroreflex mechanisms was suggested.

K0031 TID-5764

AUTHOR White, C. S., and Richmond, D. R.

TITLE Blast Biology

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepred for Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D.C., September 18, 1959

ABSTRACT Selected information from the literature and new experimental data regarding the biologic consequences of exposure to the several environmental variations associated with actual and simulated explosive detonations were reviewed. background, brief and elementary remarks concerning blast physics and terminology were set forth. The scope of what now comprises the field of blast biology was noted to include primary, secondary, tertiary and miscellaneous blast effects as those attributable, respectively, to variations in environmental pressure, trauma from blast-produced missiles (both penetrating and nonpenetrating), the consequences of physical displacement of biological targets by blast-produced winds and hazards due to ground shock, dust and thermal phenomena not caused by thermal radiation per se. Primary blast effects were covered in detail noting physical-biophysical factors contributing to the observed pathophysiology. Also, a simple hydrostatic model was utilized diaphragmatically in pointing out possible etiologic mechanisms. The gross biologic response to single, "fast"-rising overpressures were described as was the tolerance of mice, rats, guinea pigs and rabbits to "long"-duration pressure pulses rising "rapidly" in single and double steps. Further, a few data were noted regarding biological response to "slowly" rising overpressures of "long" duration. Attention was called to the similarities under certain circumstances between thoracic trauma from nonpenetrating missiles and that noted from air blast. The association between air emboli, increase in lung weight (hemorrhage and edema) and mortality was discussed. Information relevant to the clinical symptoms and therapy of blast injury was presented and the needs for additional investigations were emphasized. The relation of blast hazards to nuclear explosions was assessed and one approach to predicting the maximal, potential casualties from blast phenomena was presented making use of arbitrary and tentative criteria. Finally, the sound sense of practicing blast, radiation and thermal prophylaxis as a means of minimizing casualties was urged as an essential step to enhance individual and national survival in the event of nuclear war.

K0032 TID-5564

AUTHOR White, C. S.

TITLE Biological Blast Effects

SOURCE Progress Report, Lovelace Foundation for Medical Education and Research, prepared for U.S. Atomic Energy Commission, Technical Information Service, Washington, D. C.

ABSTRACT Introduction: This presentation, though generally concerned with biological effects of airborne blast phenomena, will be limited to deal briefly with three main topics. First, the scope and nature of the several blast hazards will be delineated. Secondly, tentative criteria for threshold damage to humans will be set forth. Thirdly, these criteria will be related to nuclear weapons in terms of ground ranges and areas involved for 1 MT and 10 MT surface detonations, and to allow appreciation of the relative importance of blast with other effects, appropriate values for ionizing and thermal radiation will be noted.

K0033 ITR-1502

AUTHOR Greig, A. L., and Pearse, H. E.

TITLE Thermal Radiation Measurements (Parts I and II), Project 39.3: Operation Plumbbob

SOURCE Preliminary Report. Operation Plumbbob, Nevada Test Site, May-October 1957, Lovelce Foundation for Medical Education and Research, prepared for Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D. C., May 23, 1958

ABSTRACT Part I: The objective of Part I of Project 39.3 was to measure transient air temperature at selected locations in the blast-biology underground shelter in Area 1 for shot Galileo, Operation Plumbbob. The procedure used in making these measurements was similar to those techniques used by the Naval Radiological Defense Laboratory in making air-temperature measurements in Operation Teapot, 1955. No data were obtained form this shot owing to failure to one recorder at zero time. The record from the second duplicate recorder and sensing devices was lost in the developing process because of failure to anticipate an overexposure of the film to the high prompt-gamma emission from the detonation; also it is possible that this recorder stopped before zero time. Evaluation of the equipment used shows that, if equipment is modified or redesigned to be compatible with now known conditions, measurements of rapidly changing air temperatures can be made at distances in close proximity to Ground Zero.
Part II: The objective of Part II of Project 39.3 was to evaluate thermal burns from a nuclear explosion on biological receivers in a shelter. Eight Chester White pigs were used as test animals. One pig in the entrance and one about 3 ft inside the door received severe burns. These burns were carbonized on the surface and caused transepidermal damage with up to 0.3 mm penetration into the dermis. Animals away from the entrance and those in the slow fill side received no burns.. The possible sources of this damaging thermal energy are discussed.

K0034 TID-6056

AUTHOR Richmond, D. R., Taborelli, R. V., Sherping, F., Wetherbe, M.B., Sanchez, R, T., Goldizen, V. C., and White, C. S.

TITLE Shock Tube Studies of the Effects of Sharp-Rising, Long-Duration Overpressures on Biological Systems

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for U. S. Atomic Energy Commission, Office of Technical Information, March 10, 1959

ABSTRACT A closed-end shock tube was used to study the effects of single and step-wise, fast-rising overpressures of long duration on four species of experimental animals.
For animals exposed side-on against the end-plate to single, sharp-rising pressure pulses, the reflected pressures necessary to kill 50 per cent (LD50) were as follows: for the mouse, 29.8 +- 1.1; rabbit, 33.4 +- 1.2; guinea pig, 36.7 +- 0.7; and the rat, 38.7 +- 0.6 psi.
Animals located at short distances away from the end-plate were loaded in a two-step manner. The steps corresponded to the incident and reflected shock fronts. With stepwise increases in pressure, animals tolerated much higher reflected overpressures than when the pressure load consisted of a single, sharp-rising pulse.
The importance of the time interval between step loads was pointed out and briefly discussed.

K0035 WT-1470

AUTHOR Goldizen, V. C., Richmond, D. R., Chiffelle, T. L., Bowen, I. G., and White, C. S.

TITLE Missile Studies With a Biological Target, Project 33.4, Operation Plumbbob, Nevada Test Site, May-October 1957,

SOURCE Report to the Test Director, Civil Effects Test Group, Lovelace Foundation for Medical Education and Research, U. S. Atomic Energy Commission, Office of Technical Services, Department of Commerce, Washington, DC, January 23, 1961

ABSTRACT Fourteen dogs were exposed on the lee side of planted gravel, of a concrete-block wall, and of glass mounted in the open and in houses to the environmental variations associated with full-scale nuclear detonations. Aluminum foil was used to protect the animals from thermal effects. The missile environment was monitored through the use of quantitative missile-trapping techniques. Pressure-time variations in the environment were also recorded. Biologic damage from overpressure and missiles was determined, and the associations between physical environmental factors and biologic response were noted and analyzed. The feasibility of utilizing missile data, along with other available information from the literature, as a means of quantitatively assessing biologic hazard was established by the close correspondence between observed and predicted dangerous wounds. This test provided full-scale validation of procedures and experiments worked out chiefly in the laboratory.

K0036 AECU-3574

AUTHOR Chiffelle, T. L., Sherping, F., Goldizen, V. C., and C. S. White

TITLE A Study of the Tissue Response to Sterile Deposits of Particulate Material

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, U. S. Atomic Energy Commission Technical Information Service Extension, Oak Ridge Tennessee, Office of Technical Services, Department of Commerce, Washington, D. C., October 1957

ABSTRACT Thirty-seven sterile materials of common construction usage, common lubricants, and sample of wearing apparel were injected as finely divided particles into the subcutaneous soft tissues of guinea pigs, each in six different sites. At intervals of 3, 7, 14, 21, 30, and 60 or 90 days, an inoculation site of each material was excised, in toto, fix, and examined microscopically. In addition, ten selected materials were injected into the liver and spleen and deposited on the omentum and mesentery of four guinea pigs for each material type, At intervals of 7, 14, 21, and 30 days, one of each group of four animals was sacrificed and a block of tissue containing the inoculum was removed from the tissues and organs, fixed, and examined histologically. The majority of materials induced only a mild and delayed inflammatory response followed by encapsulation at the end of 14 days and a relatively inert fibrous nodule produced by the 21st or 30th day. Copper particles incited a marked inflammatory response with abscess formation which persisted until the 90th day, although showing signs of subsiding at this time. Cadmium lesions were characterized by a peculiar zone of necrosis about the particle aggregate which persisted until the 60th day. Duraluminum of one type incited a pseudoneoplastic fibrous response. Axle grease, in the early stages, induced one of the most intense acute inflammation, in contrast to that produced by motor oil and ordinary lubricating grease, but the process had subsided and was fibrosed by the end of 30 days.

K0037 AECU-3272

AUTHOR Clapper, W. E., and Meade, G. H.

TITLE The Effect of Foreign Body Particles on Infections in Mice

SOURCE Final Report, Lovelace Foundation for Medical Education and Res., U. S. Atomic Energy Commission, Technical Information Service Extension, Oak Ridge, Tennessee, Office of Technical Services, Department of Commerce, Washington, D. C., August 15, 1955

ABSTRACT The effect of aluminum, motor oil, plasticrete, and indoor wall plaster on infections produced by pneumococci, E. coli, S. aureus, B. subtilis, Proteus, and Cl. Sporogenes was determined. No effect was observed on the death rate from the pneumococcal infection with any of the agents. Motor oil increased the death rate and size of the abscesses formed by E. coli and by S. aureus. It conferred some ability to attack tissue on the otherwise innocuous B. subtilis. Abscesses were somewhat greater than Proteus infections. There was a very pronounced stimulation in ability to damage tissue by Cl. Sporogenes, which alone had no effect. There was some indication that aluminum increased the size of abscesses made by S. aureus and Proteus, but not with E. coli or Cl. Sporogenes. Plasticrete produced some lesions with Cl. Sporogenes which in itself was ineffective. A slight enhancement of invasiveness of E. coli and S. aereus was observed with indoor wall plaster. Aluminum alone did not grossly damage the surrounding tissue. It was walled off with no inflammation. The motor oil was encapsulated with no visible change in the tissue. With the exception of one experiment with plasticrete, neither this nor wall plaster produced any gross tissue changes. All of the agents enhanced the invasiveness of one or more of the organisms but the motor oil was by far the most effective. The possibility, therefore, exists of flying debris from explosions influencing the character of an infection with organisms commonly found in the soil or even conferring pathogenicity to an otherwise harmless bacterium.

K0038 AECU-3267

AUTHOR Clapper, W. E., and Meade, G. H.

TITLE Radiation Effects on a Pneumococcal Inflection Produced by Subcutaneous Injections Into White Mice

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, U. S. Atomic Energy Commission, Division of Technical Information, Oak Ridge, Tennessee, Office of Technical Services, Department of Commerce, Washington, D. C., October 1953

ABSTRACT SUMMARY: Whole-body x-irradiation of white mice with 350 r effects an infection with pneumococci induced by subcutaneous inoculation as follows: 1. Little or no effect is observed when radiation exposure is given at the same time as the inoculation of the bacteria. 2. Death rate is increased and the time required for bacteremia to become established is reduced when radiation exposure is given 3 days prior to inoculation. The time from bacteremia to death is not changed. 3. Death rate is increased, and the time from bacteremia to death is reduced when radiation exposure is given 6 days prior to inoculation. The time required for bacteremia to become established is not changed.

K0039 CEX-71.1

AUTHOR White, C. S.

TITLE The Nature of the Problems Involved in Estimating the Immediate Casualties From Nuclear Explosions

SOURCE Technical Report, Lovelace Foundation for Medical Education & Res., U. S. Atomic Energy Commission, Div. of Technical Information, Oak Ridge, Tennessee, National Technical Information Service, U. S. Depart. of Commerce, Springfield, VA, July 1971

ABSTRACT It was pointed out that considerable progress has been made in assembling range-yield-effects data for nuclear detonations applicable today to a variety of burst conditions and that tentative though incomplete biomedical criteria have been formulated for assessing the hazards of exposure to blast as well as ionizing and thermal radiations. Even so, it was noted that great care must be taken if meaningful concepts are to come from a combined use of the physical and biomedical data.

In emphasis of this fact, the physically and biologically oriented problem areas were presented and discussed. Also, survival data for the Hiroshima explosion were used to show that the conditions of exposure more than any other factors determined immediate survival and more than anything else were responsible for keeping the casualty figures as low as they were.

A major deterrent in applying the experience in Japan to a more generalized situation is the lack of information about the differences between "free-field" parameters and the environmental variations that will actually occur at the locations of people immediately following the burst. The relevant problems are complex and difficult and there has been neither widespread appreciation of the need to "move out of the streets and into exposure locations" nor with one exception much progress in translating "free-field dose" to "exposure dose" at locations of interest. The exception is the Ichiban I Program carried out corporatively by personnel from Oak Ridge National Laboratory and the Atomic Bomb Casualty Commission.

A second difficulty in generalizing across the range-yield spectrum of effects is the fact that, all other things being the same, the ratios of the major effects parameters to one another change with yield, viz., the range-yield-effects curves for thermal and ionizing radiation for blast are not parallel with one another.

Even so, tentative biological criteria can be combined with range-effects data for different yields and burst conditions to define the ranges inside which and the areas over which specified potential hazards exist. Also, given a completely flat terrain, the absence of structures and all people exposed in the open, casualty estimates for such "free-field" exposure conditions might perhaps be credible. In the presence of terrain variations and the many types of buildings in cities and urban complexes, there can be no satisfactory predictions until positional, geometric and orientational factors along with others defining the conditions of exposure have been recognized and assessed. The state of the art currently does not include this sophistication and any but the grossest estimation of nuclear casualties is hardly possible today.

K0040 CEX-58.8

AUTHOR White, C. S., Bowen, I. G., Richmond, D. R., and Corsbie, R. L.

TITLE Comparative Nuclear Effects of Biomedical Interest

SOURCE Civil Effects Test Operations Report, Lovelace Foundation for Medical Education & Research, Albuquerque, NM prepared for Civil Effects Test Operations, US Atomic Energy Commission, Division of Biology and Medicine, Washington, D. C., September 1960

ABSTRACT Selected physical and biological data bearing upon the environmental variations created by nuclear explosions are presented in simplified form. Emphasis is placed upon the "early" consequences of exposure to blast, thermal radiation, and ionizing radiation to elucidate the comparative ranges of the major effects as they vary with explosive yield and as they contribute to the total hazard to man. A section containing brief definitions of the terminology employed is followed by a section that utilizes text and tabular material to set forth events that follow nuclear explosions and the varied responses of exposed physical and biological materials. Finally, selected quantitative weapons-effects data in graphic and tabular form are presented over a wide range of explosive yields to show the relative distances from Ground Zero affected by significant levels of blast overpressures, thermal fluxes, and initial residual penetrating ionizing radiations. However, only the "early" rather than the "late" effects of the latter are considered.

K0041 WT-1507

AUTHOR Richmond, D. R., White, C. S., Sanchez, R. T. and Sherping, F.

TITLE The Internal Environment of Underground Structures Subjected to Nuclear Blast. II. Effects on Mice Located in Heavy Concrete Shelters

SOURCE Report to the Test Director, Lovelace Foundation for Medical Education and Research, Civil Effects Test Group, Atomic Energy Commission Technical Information Service, Oak Ridge, Tenn., Technical Services, Department of Commerce, Washington, D. C.

ABSTRACT A cage containing 20 mice was placed in each of 12 underground shelters tested on shot Smoky in an attempt to assess biologically the inside environment of the shelters. Two samples of 20 mice each acted as controls. The structures, of French and German design, were located at ranges between 840 ft and 320 ft from Ground Zero. Shot Smoky, a nuclear device, was exploded atop a 700-ft tower and had a yield of 43 kt.

All but one group of mice were recovered on D+2 days. Aside from two samples placed in unrealistic locations, all animals were alive at recovery. With one exception, the peak pressures in the chambers that contained mice were insignificant, ranging from a fraction of 1 psi to 1.6 psi. The one high pressure of 14.4 psi did not kill any of the mice. According to the film-badge dosimeters, one group of mice received 190 r of gamma radiation. The others were exposed to 54 r of gamma or less.

The mice were observed for a 60-day postshot period. The deaths that occurred were attributed to a Salmonella infection in the animal colony and not to radiation.

Although the gamma radiation doses that most of the animal groups received were low, the levels that existed in the main chambers near the entry doors of the German shelters were over 100 r, a biologically significant dose. In contrast, the environment within two of the French shelters appeared to be quite acceptable.

K0042 WT-1469

AUTHOR Taborelli, R. V., Bowen, I. G. and Fletcher, E. R.

TITLE Tertiary Effects of Blast--Displacement, Operation Plumbbob, Project 33.3

SOURCE Report to the Test Director, Lovelace Foundation for Medical Education and Research, U. S. Atomic Energy Commission, Civil Effects Test Group, Office of Technical Services, Department of Commerce, Washington, DC, February 1959

ABSTRACT The objective of Project 33.3 was to determine the velocity-time and distance-time histories of anthropomorphic dummies and equivalent spheres (idealized models having an acceleration coefficient a equal to that of the dummy) displaced by blast winds. The dummies and spheres were located at stations within regions of about 5 and 7 psi overpressures.

The technique used for recording the movement of these objects was phototriangulation. Analysis of the films obtained gave the velocity and distance in the case of one shot. In a second shot the field of view was obscured by smoke (perhaps dust too) before any motion could be recorded by the cameras.

In one phase of the experiment, equivalent spheres were caught in flight at near predicted maximum velocity by missile traps. The depth of sphere penetration in the calibrated capture medium was then used to compute the sphere velocity.

K0043 WT-1467

AUTHOR Richmond, D.R., Taborelli, R.V., Bowen, I. ., Chiffelle, T.L., Hirsch, F.G., Longwell, B.B., Riley, J. G., White, C.S., et al

TITLE Blast Biology--A Study of the Primary and Tertiary Effects of Blast in Open Underground Protective Shelters, Operation Plumbbob, Project 33.1

SOURCE Report to the Test Director, Lovelace Foundation for Medical Education and Research, U.S. Atomic Energy Commission, Civil Effects Test Group, Office of Technical Services, Department of Commerce, Washington, DC, February 1959

ABSTRACT Dogs, pigs, rabbits, guinea pigs, and mice were exposed to nuclear detonations in two open underground partitioned shelters. The shelters were of similar construction, and each was exposed to separate detonations Each inner chamber filled through its own "orifice"; thus four separate pressure environments were obtained. An aerodynamic mound was placed over the escape hatch of each structure to determine its effect on the pressure-curve shape inside the chamber. In one test a sieve plate bolted across the top of the mound was evaluated. Wind protective baffles of solid plate and of heavy wire screen were installed in the shelters to compare primary and tertiary blast effects on dogs. The shelters also contained static and dynamic pressure gauges, radiation detectors, telemetering devices and, in one test, air-temperature measuring instruments, dust-collecting trays, and eight pigs for the biological assessment of thermal effects.

One dog was severely injured from tertiary blast effects associated with a maximum dynamic pressure (Q) of 10.5 psi, and one was damaged with a maximal Q of 2 psi. Primary blast effects resulting from peak overpressures of 30.3, 25.5, 9.5 and 4.1 psi were minimal. The morality was 10 per cent of the mice exposed to a peak pressure of 30.3 psi and 5 and 3 per cent of the guinea pigs and mice exposed to a peak pressure of 25.5 psi. Many of the rabbits, guinea pigs, and mice sustained slight lung hemorrhages at maximum pressures of 25.5 and 30.3 psi. Eardrum perforation data for all species, except mice, were recorded.

Following shot 2, thermal effects were noted. Animals of the groups saved for observation have died from ionizing-radiation effects.

K0044 WT-1179

AUTHOR White, C.S, Chiffelle, T.L., Richmond, D.R., Lockyear, W.H., Bowen, I.G., Goldizen,V.C., Merideth, H.W., Kilgore, D.E., et al

TITLE Biological Effects of Pressure Phenomena Occurring Inside Protective Shelters Following a Nuclear Detonation, Operation Teapot, Project 33.1

SOURCE Report to the Test Director, Lovelace Foundation for Medical Education and Research, U.S. Atomic Energy Commission, Civil Effects Test Group, Office of Technical Services, Department of Commerce, Washington, D.C., October 1956

ABSTRACT In two series of experiments 277 experimental animals, including 66 dogs, 52 rabbits, 52 guinea pigs, 63 rats, and 44 mice, were exposed under selected conditions in six different general types of instruments above- and below-rgound shelters to blast produced by nuclear explosions. The distance of the several structures form Ground Zero ranged from 1050 to 5500 ft. The most severe alterations in the pressure environment occurring inside the structures followed the detonation of a nuclear device with a yield approximately 50 per cent greater than nominal. The highest overpressure to which animals were exposed was 85.8 psi, the rise time of which was 4 msec. The overpressure endured for about 570 msec. Overpressures ranged from this maximum downward in 15 other exposure situations to a minimum of 1.3 psi enduring for nearly 1346 msec but rising to a maximum in about 420 msec. The latter pressure occurred inside a reinforced concrete bathroom shelter, which was the only surviving part of a house otherwise totally destroyed, at 4700 ft where the outside incident pressure was about 5 psi. Following the nuclear explosions, all animals were recovered, examined, sacrificed, and subjected to gross and microscopic pathological study. All lesions were tabulated and described. The results of pressure-time data, documenting the variations on the pressure environment, are presented and analyzed, and an exploratory attempt is made to relate the alterations in the pressure environment to the associated pathology observed. A critical review of selected material from the blast and related literature is presented. All data are discussed, and the several problems related to the design and construction of protective shelters are noted and briefly, but analytically, assessed. The most outstanding contribution of the field experiments and the related study of the literature was the unequivocal demonstration that the provision of adequate protective structures can indeed be an effective means of sharply reducing casualties which would otherwise be associated with the detonation of modern large-scale explosive devices.

K0045 CEX-63.7

AUTHOR White, C. S., Bowen, I. G., and Richmond, D. R.

TITLE A Comparative Analysis of Some of the Immediate Environmental Effects at Hiroshima and Nagasaki

SOURCE Civil Effects Test Operations Report, Lovelace Foundation for Medical Education and Research, U. S. Atomic Energy Commission, Civil Effects Study, Office of Technical Services, Department of Commerce, Washington, D.C., August 1964.

ABSTRACT The problem areas of concern to those who would establish a quantitative relation between biologic response and the more immediate environmental variations caused by nuclear explosions were defined. The scope of blast and shock biology was set forth and a selective summary of current knowledge regarding biological blast effects was presented. Tentative criteria useful in assessing the hazards of some of the major nuclear effects were noted. Following elucidation of a range-yield-effects relationship applicable to high-yield explosions generally, the criteria were applied specifically to a 20-kt yield burst at heights assumed to apply to the Hiroshima and Nagasaki explosions. The procedure, establishing the range-effect relationships for the two Japanese cities, was carried out through use of the free-field scaling laws and a mathematical model allowing scaling of translational effects for both debris and man. Thus an attempt was made to predict the ranges inside which the potential existed for producing specified levels of biological damage. For each of the predicted ranges, values for overpressure, thermal and initial nuclear radiations along with translational velocities for man and glass fragments were computed to allow a more balanced appreciation of all the effects parameters that pose a hazard to man. The implications of the free-field range-effects data in interpreting some of the immediate effects at Hiroshima and Nagasaki were explored and discussed. Though the overall analytical approach allowed was thought to be useful and sound, the tentative nature of many of the numerical data presented was emphasized. Thus those numbers employed representing best current estimates as well as values arbitrarily assigned were all noted to be subject to future refinement as new information expands the understanding of nuclear phenomenology and the consequences of exposure thereto.

K0046 CEX-59.14

AUTHOR Fletcher, E. R., Albright, R. W., Goldizen, V. C., and Bowen, I. G.

TITLE Determinations of Aerodynamic-Drag Parameters of Small Irregular Objects by Means of Drop Tests

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, prepared for Civil Effects Test Operations, U.S. Atomic Energy Commission, Office of Technical Services, Department of Commerce, Washington, DC, June 1960

ABSTRACT During the 1955 and 1957 Test Operations at the Nevada Test Site (NTS), masses and velocities were determined for more than 20,000 objects, such as glass fragments from windows, stones, steel fragments, and spheres, which were energized by blast winds resulting from nuclear explosions. Following the field tests, a mathematical model was devised to help explain quantitatively the experimental results. This model required certain aerodynamic-drag information in regard to the displaced objects. It was the purpose of the study outlined in this report to determine the necessary drag properties for the objects by means of drop tests.

In addition to the objects mentioned above, small laboratory animals, mice, rats, guinea pigs, and rabbits, were used in the drop tests. The data obtained from these tests were extrapolated to estimate the drag properties for man, and the results compared favorably with data from other sources. Also, a method was developed to estimate the average drag properties of man from his total surface area, assuming that every possible orientation of a straight, rigid man with respect to the wind was equally likely.

K0047 CEX-62.2

AUTHOR Fletcher, E. R., Albright, R. W., Perret, R. F. D., Franklin, M. E., Bowen, I. G. and White, C. S.

TITLE Nuclear Bomb Effects Computer (Including Slide-Rule Design and Curve Fits for Weapons Effects

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, prepared for Civil Effects Test Operations, U. S. Atomic Energy Commission, Office of Technical Services, Department of Commerce, Washington, DC, April 1962

ABSTRACT Based on data from the 1962 edition of "The Effects of Nuclear Weapons," a circular slide rule was designed to evaluate 28 different effects of nuclear weapons. Of these 28 different effects, 13 relate to blast, 5 to thermal radiation, 1 to initial nuclear radiation, 2 to early fallout, 6 to crater dimensions, and 1 to fireball dimensions. Most of the parameters are presented as functions of range and yield (1 kt to 20 Mt). Simple techniques are described which make it possible to estimate most of the effects parameters for yields greater than 20 Mt or smaller than 1 kt. The report presents (1) curve fits of weapons-effects data, (2) design analysis for the slide rule, and (3) instructions for use of the rule along with some of the implications of the data in regard to biological and structural damage. The machine techniques are mentioned which were used to prepare the original graphs necessary for the production of the slide rule.

K0048 CEX-58.9

AUTHOR Bowen, I. G., Albright, R. W., Fletcher, E. R., and White, C. S.

TITLE A Model Designed to Predict the Motion of Objects Translated by Classical Blast Waves

SOURCE Technical Report, Civil Effects Study, Lovelace Foundation for Medical Education and Research, Civil Effects Test Operations, U. S. Atomic Energy Commission, Office of Technical Services, Department of Commerce, Washington, D.C., January 1961

ABSTRACT A theoretical model was developed for the purpose of predicting the motion of objects translated by winds associated with "classical" blast waves produced by explosions. Among the factors omitted from the model for the sake of simplicity were gravity and the friction that may occur between the displaced object and the surface upon which it initially rested. Numerical solutions were obtained (up to the time when maximum missile velocity occurs) in terms of dimensionless quantities to facilitate application to specific blast situations. The results were computed within arbitrarily chosen limits for blast waves with shock strengths from 0.068 to 1.7 atm (1 to 2 psi at sea level) for displaced objects with aerodynamic characteristics ranging from those of a human being to those of 10-mg stones and for weapon yields at least as small as 1 kt or as large as 20 mt.

K0049 DASA-1778

AUTHOR Chiffelle, T. L.

TITLE Pathology of Direct Air-Blast Injury

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for the Defense Atomic Support Agency, Washington, D.C., April 1966

ABSTRACT Blast injury is a complex and very hazardous phenomenon to the biologic target. Together with effects of thermal radiation from modern nuclear weapons, blast injury (direct and indirect) appears to be accountable for the vast bulk of early deaths and casualties in nuclear explosions. This article has attempted to summarize the important clinical, physiologic, and pathologic information concerning the effects of direct air-blast injury on the biologic subject. Certain features have been emphasized in order to assist the clinical medical officer towards proper management of casualties. A brief description of pulmonary sequelae of blast injury is included for completeness.

K0050 LF-54

AUTHOR Yelverton, J. T., Richmond, D.R., Jones, R. K., and Fletcher, E. R.

TITLE A Review of the Treatment of Underwater Blast Injuries

SOURCE Final Technical Report, Lovelace Foundation for Medical Education and Research, prepared for Department for the Navy, Office of Naval Research, Arlington, VA, National Technical Information Service, Depart. of Commerce, Springfield, VA, Sep.1976

ABSTRACT Literature on underwater blast effects in man and animals was reviewed with particular reference to its pathology, pathophysiology, and therapy. Anatomic structures which contain air, i.e., lungs, enteric tract, nasal sinuses and middle ear were found to be most vulnerable to blast injury. Lesions of greatest significance with respect to morbidity and mortality included air mechanization, pulmonary hemorrhage and enteric perforations. The frequent association of enteric perforation in the presence of impaired cardiopulmonary function in underwater blast victims represented the most difficult medical management problem.

An historical review of therapeutic procedures used in the treatment of blast injury was then presented. Factors found to be of greatest potential benefit in improving the dismal survival rate of underwater blast victims includes: (1) prevention of air embolil (2) maintenance of adequate ventilation and respiration and (3) timely surgical repair of enteric tract injuries. Therapeutic measures which might be used to achieve these ends included hyperbaric oxygen therapy, positive pressure ventilation and membrane oxygenation. Limitations in our current knowledge were discussed and several potentially fruitful research projects were identified.

K0051 LF-55

AUTHOR Fletcher, E. R., Yelverton, J. T., and Richmond, D. R.

TITLE The Thoraco-Abdominal System's Response to Underwater Blast

SOURCE Final Technical Report, 1 June 74 to 30 Sep 76, Lovelace Foundation for Medical Education and Research, prepared for Office of Naval Research, Arlington, VA, September 1976

ABSTRACT The purpose of this study was to model the response of the thoraco-abdominal system to underwater-blast waves. The effort focused on the dynamics of submersed gas bubbles because previous studies had shown that most injuries occurred to the gas-containing organs and the immediately adjacent tissues.

Experiments were conducted to obtain data for use as input in the development of a model. Gas-containing balloons, excised organs (swim bladders, gut sections and sheep lungs): excised organs (swim bladders and gut sections) in gelatin blocks; and whole animals (fish and rats) were viewed with high-speed cameras while being exposed to a shock wave in an underwater test chamber. Overpressure vs time was measured inside the thoraces and abdomens of sheep exposed at either of two depths to underwater blast in a test pond. Both the film and gauge records indicated that the gas bubbles enclosed in the various submersed objects underwent damped oscillations. All rupturing observed in the films occurred while the objects were expanding. In most cases, rupturing began during the first oscillation at a larger volume than the initial one.

In general, the measured frequencies and amplitudes of oscillation were shown to be consistent with the theory for spherical air bubbles undergoing adiabatic changes in free water. Although damping was neglected in this model, the predictions agreed with the measured overpressures and times associated with the first maximum compression of the thoraces of sheep exposed to impulsive loads at a depth of 10 ft. However, all of the peak overpressures measured in the abdomens as well as those measured in the thoraces of sheep near the surface were lower than predicted. Possible reasons for these discrepancies were discussed.

Arguments were presented suggesting that the severity of lung hemorrhage in personnel using scuba gear at various depths below 10 ft might be approximately constant if each diver received an impulsive load proportional to the square root of the hydrostatic pressure at his depth.

K0052 WT-1468

AUTHOR Bowen, I. G., Franklin, M. E., Fletcher, E. R., and Albright, R. W.

TITLE Secondary Missiles Generated by Nuclear-Produced Blast Waves, Project 33.2: Operation Plumbbob, Nevada Test Site, May-October 1957

SOURCE Technical Report to the Test Director, Lovelace Foundation for Medical Education and Research, U. S. Atomic Energy Commission, Civil Effects Branch, Washington, DC, Oct. 28, 1963

ABSTRACT The generation of secondary missiles by blast waves was investigated in Operation Plumbbob for three nuclear detonations with estimated yields of 11, 38, and 44.5 kt. A trapping technique was used to determine the impact velocities for 17,524 missiles (stones, glass fragments, spheres, and military debris or steel fragments) which occurred in open areas, houses, and an underground shelter with an open entryway. The equivalent ideal-wave peak overpressures computed from measured blast data for the open-area stations varied from 3.8 to 21 psi Two houses and an underground shelter were located where the overpressures were 3.8 and 65 pis, respectively. The effect of hill-and-dale terrain on the production of missiles was investigated on one of the shots. Precursor effects were noted on tow of the shots at stations near Ground Zero (GZ).

Missile velocities measured at all stations except the underground shelter were compared with those computed by use of a model based on an ideal blast wave. An analytical procedure was presented by which translational velocities of man can be estimated using the measured velocities of spheres and stones.

Total distances of displacement were measured for 145 stones that weighed up to 20 kg and for 1528 fragments from a concrete-black wall.

K0053 DASA-1858

AUTHOR Hirsch, F. G.

TITLE Effects of Overpressure on the Ear - A Review

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, November 1966

ABSTRACT This report, which is primarily a review of published material concerning the effects of blast on the human and the mammalian ear, also incorporates some previously unpublished data concerning the impact of age on the vulnerability of the tympanic membrane to blast overpressures, and some further material on intraspecies scaling.

An attempt has been made to correlate such quantitative data as can be found in the literature, but this has not been found possible of accomplishment in a completely satisfactory way. By rescaling some previously published material in view of available data, and incorporating some unpublished material a value for the threshold of eardrum rupture in man is estimated to be 5 psi, and the "short"-rising overpressure required for rupture of 50 per cent of human eardrums is 15 psi.

This information will be of use to those whose task it is to assess hazards and identify populations at risk, as well as those responsible for providing safe working environments and similar problems in the field of environmental health.

K0054 DASA-2020

AUTHOR Fletcher, E. R., Richmond, D. R., Bowen, I. G., and White, C. S.

TITLE An Estimation of the Personnel Hazards from a Multi-Ton Blast In a Coniferous Forest

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, November 1967

ABSTRACT Experiments are described which took place in a managed coniferous forest at various ranges from a 50-ton TNT surface burst. The secondary blast hazard to personnel was estimated as a function of range and type of exposure. The tertiary blast hazards were estimated using the measured blast wave parameters and a mathematical model of translation. Six anthropomorphic dummies were placed in the forest to obtain total displacements and partially verify the translation model.
The primary blast hazard was estimated from the measured blast wave parameters and earlier studies involving several mammalian species. The hazard was computed as a function of initial orientation for a man in the forest and in the open since pressure records in a cleared sector differed somewhat from those in the forest.
Measured steel-sphere velocities were used to verify the translational model and to estimate the positive dynamic-pressure impulses at three ranges in the forest and in the cleared sector. Thee impulses agreed well with those obtained by other experimenters. The forest seemed to have little effect on the impulse although the shape of the wave was apparently changed.
The over all blast hazards to personnel in a forest and in an open area are discussed in terms of range, overpressure, and type of exposure.

K0055 DASA-2113

AUTHOR Bowen, I. G., Fletcher, E. R., and Richmond, D. R.

TITLE Estimate of Man's Tolerance to the Direct Effects of Air Blast

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, prepared for the Defense Atomic Support Agency, Washington, D. C., October 1968

ABSTRACT Tolerance indices were determined, allowing for the effects of body mass, for thirteen mammalian species using the results of experiments in which animals were exposed near a normally reflecting surface to shocked blast waves whose durations ranged from 0.24 to 400 msec. A general equation was developed for expressing the interrelations between overpressure, duration of the blast wave, body mass, and probability of survival. The species were divided into high- and low-tolerance groups applicable to "large" and "small" mammals, respectively. Since the available evidence indicated that man is more likely to be a member of the high-tolerance group, the tolerance index arbitrarily, but tentatively, assigned to him was the geometric mean of those for the large species. Using criteria developed in experimental studies, the results of the overall analysis were made applicable to free-stream situations in which the long axis of the body is perpendicular or parallel to the direction of propagation of a shocked blast wave.

K0056 POR 6631 (WT-6631)

AUTHOR Fletcher, E. R., Richmond, D. R., Jones, R. K., and Jackson, W. S.

TITLE Blast Effects of Helicopter Plexiglas Windows, Middle North Series, Mixed Company Event,

SOURCE Final Project Officer's Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 18 June 1974

ABSTRACT Styrofoam witness plates and cameras were used to obtain information about the flying plexiglas fragments inside ten UH-1 helicopters in the vicinity of a 500-ton TNT detonation. The aircraft were oriented side-on and head-on in open terrain and side-on in revetments ar ranges where the peak incident overpressures were 1.2, 2.3, 3.5, 5.0, and 8.8 psi. Twelve flat panes of plexiglas mounted on cubical wooden boxes were exposed head-on to similar overpressures. Masses, velocities, and spatial densities of the fragments were detailed for the boxes and for the crew and cargo sections of the helicopters. Approximation to the mass-velocity distributions were derived using regression analyses.

K0057 POR 6622-1

AUTHOR Richmond, D. R., Fletcher, E. R., Jones, R. K., and Jackson, W. S.

TITLE Airblast Effects Inside Field Fortifications, Middle North Series, Mixed Company III Event

SOURCE Final Project Officers Report, Project LN401, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 18 June 1974

ABSTRACT Blast-displacement effects were studied with dummies in an open personnel shelter and in two fighting bunkers. The underground shelter had a 14- x 14- x 6.5-foot personnel chamber with a 2- x 4-foot opening. The shelter was 540 feet from the charge. The peak pressure measured outside the shelter was 41 psi. Inside the shelter, the pressure rose to a peak of 5.9 psi in 40 msec. Even tough the shelter roof collapsed, film records of the dummies wee obtained. A dummy standing 5 feet inside the entryway was displaced against the rear wall head first at a velocity of 16 ft/sec. Dummies located prone 4 feet from the door way and standing 10 feet from the door were only displaced 2 to 3 feet. Two dummies seated against the walls were not moved by the blast.
Two dummies were violently displaced inside a fighting bunker that was heavily damaged by an overpressure of 41 psi at the 540-foot range. In another bunker at the 620-foot range, peak pressure of 287 psi, two dummies sustained minimal damage from blast displacement. The incidence of injuries to be expected from whole-body impact against a nonyielding surface was discussed.

K0058 POR 6622-2

AUTHOR Richmond, D. R., and Jackson, W. S.

TITLE Airblast Effects in Foxholes, Middle North Series, Mixed Company Event

SOURCE Final Project Officers Report, Project LN 403, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 18 June 1974

ABSTRACT This study had two parts: one was to evaluate blast-displacement effects in foxholes using dummies, and the other was to obtain pressure-time records inside a foxhole in the far field.
One dummy was placed kneeling on one knee in an open foxhole and in a 2/3-covered foxhole at the 620-foot ground range from a 500-ton charge. The peak pressure measured on the surface was 28.7 psi and the duration was 140 msec. The dummy in the open foxhole, oriented side-on to the blast, was not displaced by the blast from its preshot location. The dummy in the 2/3-covered foxhole, that was open end-on to the blast, was slid 2 feet toward the rear wall by the blast.
Good pressure-time records were obtained inside and adjacent to the foxhole at the 1900-foot ground range. The peak pressure inside the foxhole of 5.4 psi was 1.8 times the 3 psi outside on the surface. There was remarkable agreement between the waveform recorded in the full-scale foxhole and those from 1/7-scale foxhole models in a shock tube.

K0059 DASA-1854

AUTHOR Richmond, D. R., Damon, E. G., Bowen, I. G., Fletcher, E. R., and White, C. S.

TITLE Air-Blast Studies with Eight Species of Mammals

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, August 1966

ABSTRACT A series of three experiments were carried out. (1) A total of 204 dogs and 115 goats were exposed to shock-tube and high-explosive-produced reflected shock waves ranging in duration from 400 to 1.5 msec. LD50 values, calculated by probit analysis, showed similar patterns for both species, increasing at the shorter durations by a factor of 4 or 5 above those for long durations. (2) Sixty dogs were exposed in a shock tube to "sharp"-rising overpressures of near 400-msec duration at six dose levels ranging from 9.2 to 35.8 psi. The degree of lung injury was graded and threshold for petechial hemorrhage determined. (3) Dose-response curves were compiled using data for 200 mice, 110 hamsters, 150 rats, 120 guinea pigs, and 40 rabbits exposed to "long"-duration reflected pressures in a shock tube. The tolerances (LD50) for all six species are compared. Pathological observations for all species and lung-weight data for cats and hamsters are included.
Criteria for relating biological response to the various parameters of the blast wave are discussed.

K0060 DASA-1245

AUTHOR Richmond, D. R., Bowen, I. G., and White, C. S.

TITLE Tertiary Blast Effects: The Effects of Impact on Mice, Rats, Guinea Pigs and Rabbits

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., February 28, 1961

ABSTRACT A total of 455 mice, rats, guinea pigs and rabbits were subjected to impact velocities ranging between 25 ft/sec and 51 ft/sec. The desired velocities were generated by allowing the animals to free-fall from various heights to a flat concrete pad. The ventral surface of each animal was the area of impact.
Probit analyses of the 24-hr mortality data yielded LD50 impact velocities with 95 per cent confidence limits as follows: mouse, 39.4 (37.4 - 42.0) ft/sec; rat, 43.5 (42.0 - 44.8) ft/sec; guinea pig, 31.0 (30.0 - 31.9) ft/sec; and rabbit, 31.7 (30.2 - 33.3) ft/sec. The LD50 figures for the mouse and rat were significantly higher, statistically, than those for the guinea pig and rabbit.
The small spread in the LD50 values suggested little variation in the tolerance to biological systems to impact.
Further, the steepness of the mortality curves indicated a narrow survival range to impact.
Extrapolations of the experimental data to the 70-kg animal yielded a predicted LD50 impact velocity of 26 ft/sec (18 mph). Literature relevant to the human case was reviewed and the tentative applicability of the predicted figures to adult man was discussed.

K0061 DASA 2711

AUTHOR Richmond, D. R., Fletcher, E. R., and Jones, R. K.

TITLE The Effects of Airblast on Sheep in Two-Man Foxholes

SOURCE Final Report, Operation Prairie Flat, Project LN-401, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 1 June 1971.

ABSTRACT The blast effects in rectangular two-man foxholes were evaluated using sheep. There were two open foxholes (2 x 6 x 4.5 feet) at ground ranges of 560, 650, 830, 940, and 1,300 feet from a 500-ton TNT charge. There were four one-half covered foxholes, one each at the first four ranges, all oriented end-on to the charge with their openings at the upstream ends. Two sheep were exposed in each of the 14 foxholes suspended in a vertical position. At the 830-foot range, one open and one half-covered foxhole, each with two pressure time gages, were included.
Because of an anomalous detonation, pressures measured adjacent to the foxhole layout were significantly below those predicted. Moreover, luminous jets emanating from the fire ball produced shock waves that preceded the main shock. This gave rise to a blast wave with double shocks known generally to be less damaging to biological systems. All the sheep survived the blast. At the 560- and 650-foot ranges (37 and 21 psi), some of the sheep sustained slight amounts of pulmonary hemorrhage. In addition, they exhibited a high incidence of eardrum rupture of a severe form. At the three greater ranges, 830, 940, and 1,300 feet (11, 8.3, and 5.5 psi, respectively), blast injuries were limited for the most part to eardrum rupture. The results obtained were discussed in relation to the pressure-time patterns recorded on the surface and in the foxholes.

K0062 DASA 2710

AUTHOR Fletcher, E. R., Richmond, D. R., and Jones, R. K.

TITLE Blast Displacement of Prone Dummies

SOURCE Final Technical Progress Report, Operation Prairie Flat, Project LN-402, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 1 June 1971

ABSTRACT Dummies were placed prone on the surface at ground ranges of 560 and 650 feet from a 500-ton charge. Dummies were also placed in slit trenches at these ranges. The overpressure measured at the 560- and 650-foot range was 37 and 21 psi, respectively, and significantly less than anticipated. The dummies on the surface were displaced from 21 to 73 feet by the blast and the peak velocities were estimated to be from 31 to 70 ft/sec. The side-on dummies were translated farther than the end-on ones at corresponding ranges. The dummies were translated father than the end-on ones at corresponding ranges. The dummies remained in the slit trenches without undergoing significant movements. Dummies deviated to the left of the radial line from ground zero because of nonradial winds associated with the anomalous detonation. Reasonable agreement was found between the predicted displacements based on an existing model and the available data.

K0063 DASA 2708

AUTHOR Damon, E. G. and Jones, R. K.

TITLE Comparative Effects of Hyperoxia and Hyperbaric Pressure in Treatment of Primary Blast Injury

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., 1 March 1971

ABSTRACT Guinea pigs and rabbits were exposed to lethal, reflected pressures in air-driven shock tube and were subsequently treated in a hyperbaric chamber in which the oxygen tension (PO2) and chamber pressure were independently varied. Treatments involving increases in PO2 resulted in increased survival times of guinea pigs whereas pressurization for 30 minutes at 36 or 72 psig with the PO2 retained at the normal ambient level by use of an N2-air mixture had no detectable effect on survival times of the animals.

To study the effects of prolonged hyperbaric oxygenation in treatment of blast injury, guinea pigs and rabbits were treated on a 29-hour schedule having an initial 3-hour hold at the pressure-treatment level followed by 26 hours for decompression. In rabbits, an initial PO2 of 17;5 psia, achieved either by air pressure at 72 psig or by pressurization to 15 psig with 65-percent O2, 35-percent N2, resulted in full survival and recovery of all treated animals. In guinea pigs, treatment with 100-percent O2 at .5 psig (PO2 = 17.5 psia)or at 12 psig (PO2 = 24 psia) resulted in increased survival times with no increase in overall survival and recovery in the first case and significantly increased survival and recovery compared to that of untreated controls in the second case.

The pathophysiology of primary blast injury is discussed with special reference to the roles of air embolism and cardiopulmonary pathology in the etiology of death.

K0064 DASA 2707

AUTHOR Yelverton, J. T., Viney, J. F., Jojola, B. III, and Jones, R. K.

TITLE The Effects of Exhaustive Exercise on Rats at Various Times Following Blast Exposure

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 1 April 1971

ABSTRACT A series of four swim experiments using a 20 degree C water bath was conducted with female, albino rats, Sprague Dawley strain. The purpose of the study was to: (1) investigate the effects of exhaustive exercise on rats at various times after exposure to airblast, (2) determine a time when exercise ceases to influence the mortality of blast-injured animals, and (3) estimate the recovery time required after blast trauma before maximum or near-maximum exercise capability is restored.

It was found that rats which were forced to swim to exhaustion as late as 1 hour following exposure exhibited a fourfold increase in lethality over nonexercised rats exposed to the same blast levels, and that exercise continued to exert an influence on blast lethality at 4 hours following exposure. However, the added stress of swimming did not increase lethality at 2 hours or 7 days. In addition, a near-normal swim performance was apparent at 7 days after traumatization.

K0065 DASA 2659

AUTHOR Bogo, V., Hutton, R. A., and Bruner, A.

TITLE The Effects of Airblast on Discriminated Avoidance Behavior in Rhesus Monkeys

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 1 March 1971

ABSTRACT Eighteen monkeys, trained to perform auditory and visual discrimination avoidance tasks, were exposed to a reflected shock-tube airblast of 30, 40, or 50 psi. Results indicated that: (1) immediate but transient performance decrement occurred; (2) latency was more affected than accuracy, particularly for the 50-psi group; (3) performance decrement was mild and recovery time brief (usually under 4 hours) despite frank physical injuries; and (4) auditory discrimination underwent more decrement than visual, with eardrum injury occurring frequently.

K0066 DNA 4048T

AUTHOR Bruner, A.

TITLE Effects on Blood Pressure and Heart Rate of Selective Shielding of Midline Trunk Structures in Monkeys Exposed to 1000 Rads 60Co

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 18 June1976

ABSTRACT Blood pressure and heart rate were monitored in three groups of shielded, nonperforming monkeys, and one unshielded control during and after exposure to 1000 rads 60Co at 150 rad/min. A narrow, vertically-oriented lead shield was located over either the dorsal midline (vertebral column) or laterally just to the left or right of midline in the three shielding groups. Purpose was to determine if selective shielding or underlying structures (e.g., spinal cord, autonomic ganglia, heart, spleen, etc.) would alter the postradiation hypotensive response. No differential effects of shielding placement of BP or HR were observed, nor did the shielding groups differ from the unshielded. Absence of radiosensitive target organs implies the hypotensive trigger site is diffuse, for example, the peripheral vasculature.

K0067 DNA 3159T

AUTHOR Bruner, A., Bogo, V., and Jones, R. K.

TITLE Delayed Match-to-Sample Performance Decrement in Monkeys Following Cobalt-60 Irradiation

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 10 August 1973

ABSTRACT Fifteen and sixteen monkeys were trained, respectively, on a delayed match-to-sample (DMTS) task and a visual memorization task, and received single, wholebody exposures of from under 1000 to 2000 rads, at 160-220 rads/minute, midbody dose of Cobalt-60 gamma. The DMTS animals showed clear early performance decrement in 13 out of 15 cases, including four incapacitations. The memorization animals tended to show either no decrement or incapacitation (5 out of 16). Group differences were explained on the basis of task complexity, with the memorization task considered insensitive to gradations of decrement. The DMTS monkeys showed clear decrement at lower doses (<1000 rads) than heretofore reported. This was considered a function of gamma effectiveness, task complexity and measurement sensitivity. Dose-rate seemed unimportant as the first signs of physiological and behavioral collapse appear at the same time following exposure onset for a wide range of dose rates in excess of 150 rads/minute, and the frequency and degree of early performance decrement and incapacitation may remain unchanged until total doses exceed 2600 rads. The minimum effective midbody dose for inducing decrement on a complex task was estimated to be 300 rads.

K0068 AGARD-CP-88-71

AUTHOR White, C. S., Jones, R. K., Damon, E. G., Fletcher, E. R., and Richmond, D. R.

TITLE The Biodynamics of Air Blast

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Proceedings AGARD Conference Proc. No 88 on Linear Acceleration of Impact Type, Oporto, Portugal, 23-26 Jan 1971

ABSTRACT After pointing out accelerative and decelerative events are associated with the direct (pressure) and indirect (translational events including penetrating and nonpenetrating debris and whole-body impact) effects of exposure to blast-induced winds and pressure variations, some of the relevant biophysical parameters were selectively noted and discussed. These included the pressure-time relationship; species differences; ambient pressure effects; the significance of positional (orientational) and geometric (situational) actors as they influence the wave form, the pressure "dose" and the biologic response; and data bearing upon the etiology of blast injury The consequences of pressure-induced violent implosion of the body wall and the significance of the associated variations in the internal gas and fluid pressures were described and emphasized as were alternating phases of "forced" hemorrhage and arterial air embolization, fibrin thrombi, coagulation anomalies and renal, cardiac and pulmonary sequelae. Tentative biomedical criteria consistent with recent interspecies scaling and modeling studies assessing primary blast hazards were presented.

K0069 DNA 3677T

AUTHOR Yelverton, J. T., Richmond, D. R., Hicks, W., Saunders, K., and Fletcher, E. R.

TITLE The Relationship Between Fish Size and Their Response to Underwater Blast

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D. C., 18 June 1975

ABSTRACT Fish were exposed to underwater blasts in an artificial pond, 220 x 150 ft, that was 30 ft deep. The underwater-blast impulse levels required for 50-percent mortality, 1-percent mortality, and no-injuries were determined for eight species of fish. There was good correlation between the LD50 impulse and the body weight of the fish. These ranged from 1.7 psi.msec for 0.02-g guppy fry to 49.5 psi.msec for 744-g carp. No difference was detectable in the underwater blast response of fish that had ducted swimbladders and those that had nonducted swimbladders. Application of the results of this study to predicting the response of fish to underwater explosions was discussed.

K0070 DNA 3114T

AUTHOR Yelverton, J. T., Richmond, D. R., Fletcher, E. R., and Jones, R. K.

TITLE Safe Distances from Underwater Explosions for Mammals and Birds

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 13 July 1973

ABSTRACT Tests were run to determine the far-field underwater blast effects on mammals and birds. The tests were conducted in a specially constructed test pond facility, 220 by 150 feet at the surface and 30 feet deep over the 30- by 100-foot center portion. Explosive charges weighing up to 8 pounds were detonated at 10-foot depths.
Sheep, dogs, and monkeys were suspended in the water, mostly with their long axis perpendicular to the surface at 1, 2, and 10 ft depths. The duck was selected as a model to represent birds on the surface and birds that dive beneath the surface. Ducks were tested on the water surface and at 2-foot depths.
The nature of the immersion-blast injuries was described and related to the impulse measured in the underwater blast wave. Impulse levels which were safe and which produced injuries in mammals and birds were presented. Underwater-blast criteria were presented which corresponded to safe and damaging impulse levels for birds and mammals along with curves relating the impulse criteria as a function of range and charge weight.

K0071 DNA 3002T

AUTHOR Henderson, T. R. and Jones, R. K.

TITLE Organic Acids as Metabolic Indicators - The Metabolism of 14C-Propionate in Rats Exposed to Irradiation and Thermal Injuries

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, D.C., February 1973

ABSTRACT 14C-propionate utilization was found to be a useful in vivo indicator of the severity of burn or irradiation injuries and the extent of recovery from such injuries. Flash burns (91.2 cal/cm2, 30 percent of body area) or gamma irradiation (750 rad) produced a significantly reduced rate of 14CO2 production from 1-14C-propionate during the initial shock phase following exposure. Recovery from nonlethal injuries was associated with recovery of ability to oxidize propionate within 1 to 2 weeks. In the case of animals exposed to irradiation plus flash burns, a greater initial decrease in propionate oxidation was noted, and recovery did not occur. The persistence of decreased rates of propionate oxidation often was correlated with early mortality.
Analysis of urinary organic acid excretion patterns showed that healthy rats excreted mainly 14C-citrate after being injected with 14C-propionate. Following exposure to injury, the excretion of 14C-citrate was reduced markedly. Recovery of citrate excretion to normal ensued in 2 to 7 days in animals exposed to nonlethal flash burns or gamma irradiation alone, but little recovery was noted in animals exposed to both injuries.
It was concluded that a deficiency of Krebs' cycle intermediates was a significant characteristic of the initial metabolic state or "ebb" phase following injuries and that biochemical events sensitive to irradiation were involved in recovery. Measurements of the rate and pathway of propionate utilization appeared to be a useful physiological monitor for estimating the extent of recovery from thermal burns.

K0072 DNA 3779T

AUTHOR Fletcher, E. R., Yelverton, J. T., Hutton, R. A., and Richmond, D. R.

TITLE Probability of Injury from Airblast Displacement as a Function of Yield and Range

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 29 October 1975

ABSTRACT The purpose of this study was to predict the probability of impact injuries due to whole-body translation by airblast as a function of yield and ground range. Predictions were made for personnel in different orientations in open terrain and near structural complexes.
A mathematical model was used to calculate the time-displacement history of personnel from considerations of aerodynamic drag and ground friction. Predicted values of maximum velocity, displacement at maximum velocity, and total displacement were tabulated for 1224 exposure conditions. These conditions included both air and surface bursts with yields from 1 T to 100 MT and peak overpressures from 2 to 97 psi.
Biological criteria were presented which indicate that personnel subjected to decelerative tumbling over open terrain can tolerate much higher velocities than personnel impacting a nonyielding, flat surface at normal incidence. These criteria were used in preparing range-yield plots for 1-, 2.5-, 5-, and 50-percent probabilities for serious injury to prone personnel in the vicinity of a surface burst.
Methods for extending the presented results to other exposure conditions were discussed.

K0073 DNA 3314T

AUTHOR Damon, E. G., Richmond, D. R., Fletcher, E. R., and Jones, R. K.

TITLE The Tolerance of Birds to Airblast

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 23 July 1974

ABSTRACT The response to birds to airblast was studied. The direct blast (overpressure) effects in quail, chickens, two-week-old chickens, and geese were determined by placing them at the end of a closed shock tube. Pigeons in flight were subjected to blast from 64-lb charges. The criteria for direct-blast effects, based on the peak pressures, were no injuries, 5 psi; injuries, 10 psi; and 50-percent mortality, 20 psi. Blast-displacement effects were evaluated by translating quail, chickens, and pigeons from the end of a shock tube. The criteria for blast displacements, based on dynamic-pressure impulse, were no injuries 5 psi.msec and injuries, 10 psi.msec. Curves relating these criteria as a function of charge weight and ground range were presented.

K0074 DASA 1856

AUTHOR White, C. S.

TITLE The Scope of Blast and Shock Biology and Problem Areas in Relating Physical and Biological Parameters

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, November 1966

ABSTRACT A few introductory remarks were followed by a brief discussion of the nature of hazards from air blast noting those due (a) directly to variations in pressure and (b) indirectly to the impact of penetrating and nonpenetrating, blast-energized missiles and the consequences of whole body displacement due to blast-induced winds or ground shock. The need for developing biomedical criteria based upon critical and measurable biological responses following exposure to significant and monitorable physical parameters was discussed in relation to hazards assessment. Also the multifaceted problem of tying up such information with blast-induced variations in the environment that occur free-field and under various conditions of exposure was noted and emphasized.

K0075 DNA 5593T

AUTHOR Fletcher, E. R., Richmond, D. R., and Yelverton, J. T.

TITLE Glass Fragment Hazard from Windows Broken by Airblast

SOURCE Topical Report, Lovelace Biomedical and Environmental Research Institute, prepared for Defense Nuclear Agency, Washington, DC, 30 May 1980

ABSTRACT This report presents shatter overpressures as a function of window size and orientation. Average values for fragment velocity, mass, and spatial density are given in relation to blast overpressure. The velocities of fragments for 50-percent probability of skin and body-wall penetration in addition to skull fracture are presented as functions of fragment mass. The protection afforded by clothing is indicated. The number of wounds and their severity is predicted as a function of either fragment velocity or blast overpressure for people behind windows in structures.

K0076 DNA 2989F

AUTHOR Damon, E. G., Henderson, E. A., and Jones, R. K.

TITLE The Effects of Intermittent Positive Pressure Respiration on Occurrence of Air Embolism and Mortality Following Primary Blast Injury

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, January 1973

ABSTRACT Twenty beagle dogs were exposed in pairs to airblast on the endplate of a 42-inch diameter shock tube. One dog of each pair then was given intermittent positive pressure respiration (IPPR) for 2 hours with 100 percent oxygen, and the other dog was maintained on 100 percent oxygen for 4 hours in a hyperbaric chamber at a chamber pressure of 14 psia, after which she was given IPPR with 100 percent oxygen for 2 hours. The mortality, time of death, and incidence of arterial air embolism in these two groups then were compared with those of 10 untreated control animals that previously had been exposed to airblast in the same way as those in the treatment groups. The mortality was 60 percent in the untreated control group, 80 percent in the immediate IPPR group, and 50 percent in the delayed IPPR treatment group. There was one case of air embolism (14-minute fatality) in the untreated control group, three cases of air embolism (5-minute, 15-minute, and 22-minute fatalities) in the immediate IPPR group, and none in the delayed IPPR group. The mean survival time for the fatalities was 12.4 hours for the untreated control group, 2.3 hours for the immediate IPPR group, and 9.9 hours for the delayed IPPR group. Thus, the results indicate that the use of IPPR immediately following blast injury may result in an increase in the incidence of air embolism, increase in mortality, and a reduction in survival time; whereas, when used after a delay of 4 hours, IPPR resulted in neither an increase in incidence of air embolism nor in mortality but did result in a shortening of survival times.

K0077 DNA 5842F

AUTHOR Richmond, D. R., Yelverton, J. T., and Fletcher, E. R.

TITLE The Biological Effects of Repeated Blasts

SOURCE Final Report, Lovelace Biomedical and Environmental Research Institute, Inc., prepared for Defense Nuclear Agency, Washington, DC, 30 April 1981

ABSTRACT The results of investigations on the biological effects of repeated blasts were reviewed. In the present study sheep and swine were subjected to multiple blasts at a rate of one per minute in a high-explosive-driven shocktube. Three 1% lethal doses (LD1) resulted in 100-percent morality in 1 hour. Blast injuries to the organs in the neck (larynx, pharynx, and trachea) and the gastrointestinal tract occurred at blast overpressure levels lower than those necessary for lung hemorrhage for both single and multiple exposures.

Curves estimating the LD1 for man as a function of incident overpressure and number of blasts were compiled. For a standing man the LD1 incident overpressure was 27 psi (186 kPa) for a single blast and 18 psi (124 kPa) for five blasts. The overpressures from one or five blasts required to inflict selected injuries in man were presented.

K0078 DNA 3463T

AUTHOR Bruner, A.

TITLE Effects of 60Co on Electrical Self-Stimulation of the Brain and Blood Pressure

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 13 December 1974

ABSTRACT The effects of 1000 and 2000 rad 60Co on electrical self-stimulation of subcortical brain areas and blood pressure were investigated to determine whether radiation-induced performance decrement occurs in a like manner for a positively-rewarded behavioral task as it does for the more typically studied shock-avoidance task. During the early postradiation minutes self-stimulation responses decreased or ceased and resumed shortly thereafter, revealing a similar course of performance decrement as seen with shock-avoidance, discrimination tasks. Early postradiation hypotension with subsequent recovery paralleled the performance decrement, reproducing the blood pressure-behavior correlations seen previously with shock reinforcement. The blood pressure elevating influence of the brain stimulation observed prior to irradiation was diminished or absent during the deep hypotensive stage postradiation, but tended to return minutes later.

K0079 DNA 2738T

AUTHOR White, C. S., Jones, R. K., Damon, E. G., Fletcher, E. R., and Richmond, D. R.

TITLE The Biodynamics of Airblast

SOURCE Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, 1 July 1971

ABSTRACT After point out that accelerative and decelerative events are associated with the direct (pressure) and indirect (translational events including penetrating and nonpenetrating debris and whole-body impact) effects of exposure to blast-induced winds and pressure variations, some of the relevant biophysical parameters were selectively noted and discussed. These included the pressure-time relationship; species differences; ambient pressure effects; the significance of positional (orientational) and geometric (situational) factors as they influence the wave form, the pressure "dose" and the biological response; and data bearing upon the etiology of blast injury. The consequences of pressure-induced violent implosion of the body pressures were described and emphasized as were alternating phases of "forced" hemorrhage and arterial air embolization, fibrin thrombi, coagulation anomalies and renal, cardiac, and pulmonary sequelae. Tentative biomedical criteria consistent with recent interspecies scaling and modeling studies for assessing primary blast hazards were presented.

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies With Animals and Man: A Walk-Up Study

SOURCE Final Report, EG&G Special Projects, Contract DAMD-17-8-C-8141, prepared for U. S. Army Aeromedical Research Laboratory, Fort Rucker, AL, September 1994

ABSTRACT The U.S. Army needs realistic safe limits for exposure to impulse noise produced by heavy weapons. Impulse noise limits, based on data from small arms, may be overly conservative. In order to define new limits for heavy weapons, this systematic 5-year study of the effects of high-intensity impulse noise on human volunteers was undertaken. The number of impulses, the peak pressure levels, and spectral distributions of energy of heavy weapon-like impulses were varied systematically. Five major groups of 273 volunteers were given a series of exposures to one of three impulse types and to three types of hearing protectors. The impulse spectrum was varied by changing the distance between the volunteer and an explosive detonation. The peak pressure level was varied in 3-dB steps by changing the weight of the explosive charge. The number of impulses per day was 6, 12, 25, 50, or 100. Volunteers wore hearing protection for all exposures. After each exposure, the amount of TTS, if any, was determined. Each volunteer started with an exposure of six impulses at the lowest intensity. If the TTS was less than 15 dB, the subject received six impulses at the next higher level the next day. This continued through all intensities. Then, the number of impulses was increased using the maximum intensity permitted by nonauditory injury limits. The first group used an earmuff with maximum intensity permitted by nonauditory injury limits. The first group, using an earmuff as a protective device, completed al exposures. The peak sound pressure levels varied from 172 to 191 dB with an A-duration of approximately 3 ms. No significant TTS (in excess of 25 dB) was observed for any condition.
The second group, using an earmuff with controlled leaks, completed the same exposures as the first group. In this case, only one of 65 subjects had a significant TTS. This was from 100 shots at 191 dB. Using the same protection, the third group was exposed to impulses with peak levels from 178 to 196 dB and with an A-duration of 800 seconds. A considerable number of subjects had significant TTS once the peak level exceeded 187 dB. Continuing with the same leaking muff, the fourth group was exposed to impulses whose peak SPL varied form 175 to 193 dB and whose average A-duration was 1.5 ms. Again, there were cases of significant TTS once the peak level exceeded 187 dB. Using the impulses of group 4, the final group was tested with earplugs with a hole through them. Compared to the leaking muffs, these plugs were completely unsatisfactory. Significant TTS started occurring at SPL levels as low as __ dB. Except for the perforated plugs, the majority of the subjects were willing to be exposed up to the threshold set by nonauditory considerations. Results of acceptability questionnaires and medical examinations also are included.

K0081

AUTHOR Fletcher, E. R. and Bowen, I. G.

TITLE Blast-Induced Translational Effects

SOURCE Annals of the New York Academy of Sciences 152(1): 378-403, October 28, 1968

ABSTRACT Summary: A revised mathematical model of blast-induced translational effects was discussed, which has two advantages over the earlier models: (1) arbitrary blast-wave forms can be used and (2) the effects of ground friction can be included if the translating object is tumbling over smooth, flat ground. For relatively short-duration blast waves (such as those produced by HE), the single most important blast-wave parameter needed to predict translation is the dynamic-pressure impulse.

Experiments involving the translational velocities of steel spheres were described, the results of which were used to estimate dynamic-pressure impulse by two methods; the first was accomplished by means of the mathematical model and the second, simplified technique only required a least-squares analysis of the experimental data. The experimental sphere velocities were compared to the velocities computed with the translation model using the blast waves predicted by various authors, and the discrepancies were discussed.

In order to understand the process of decelerative tumbling, a series of "calibration" experiments were performed. Concrete blocks, stones, and animals were dropped from a truck traveling at various speeds, and the distances between bounces and the total displacements were measured. From these experiments an "average ground friction" term was derived and included in the translation model.

The model was tested using data obtained in experiments where dummies and goats were displaced by the winds from a 500-ton TNT detonation. The computed velocities and displacements were in reasonable agreement with the experimental results except in those cases where anomalous nonradial winds were present. The model could not be adequately tested for the latter cases, since appropriate blast-wave parameters were not available.

In another experiment, the velocity distribution of the larger fragments from a concrete-block wall blown apart by the winds from an 11 kt nuclear shot was reconstructed from the measured displacement of the fragments and the "calibration" experiments. The geometric mean velocity of the fragments was shown to be in good agreement with the predicted velocity for a single loose block situation in free air.

A brief description was given of a mathematical model which was developed to study the mechanisms of decelerative tumbling for stones, blocks, and animals and to permit extrapolation to greater velocities than have heretofore been obtained experimentally. The predictions of the model were shown to be in good agreement with the results of the "calibration" experiments for block translations.

Finally, certain other translational situations were briefly discussed. These were: those involving secondary missiles generated by near-ideal and non-ideal blast waves; translation in and near structures, and crater ejecta.

K0082 CEX-58.2

AUTHOR Davis, T. P., Miller, N. D., Ely, T. S., Basso, J. A., and Pearse, H.E.

TITLE The Scattering of Thermal Radiation Into Open Underground Shelters

SOURCE Technical Report, Civil Effects Exercise, Civil Effects Test Operations, U. S. Atomic Energy Commission, Office of Technical Services, Washington, DC, October 30, 1959

ABSTRACT Animals placed in open underground shelters at the Nevada Test Site during an atomic weapon test suffered skin burns of an unknown origin. From a study of the burns, the following deductions were made: (1) the causative agent entered the shelter from outside; (2) the causative agent was subject to rectilinear propagation near the entrance; and (3) the causative agent required a relatively unobstructed opening to effect entrance.

The two most likely agents for such burns are (1) hot winds and/or hot wind-borne dust that are forced into the shelter as the shock front from the weapon passes the shelter entrances and (2) radiant energy from the fireball that is scattered into the shelter.

The purpose of this study was to evaluate the contribution made by radiant energy and, if this contribution proved to be significant, to suggest means of eliminating it. The following procedure was adopted: (1) extensive measurements were made in the laboratory on a scale model of the shelter and (2) direct measurements were made on an actual shelter to ensure the validity of the laboratory results.

A Photronic cell and a MacBeth Illuminometer were used to measure the entryway transmission of total radiant energy.

The consistency of the results with extended and point sources for the model shelter and the agreement of these results with those from a point source and sunlight for the underground shelter at the Nevada Test Site lead to considerable confidence in the ability to predict the amount of radiant energy that would reach the animals from a weapon of known size. The energy calculated on the basis of these static measurements is about 1/200 of that required to produce the burns. Although transient effects caused by the rapid heating on the entryway walls could have resulted in a considerable increase in the entryway transmission, it is felt that radiant energy was neither the sole causative agent nor the most important causative agent in producing burns within the shelters. Hot winds and/or hot wind-borne dust are now considered to be the most likely agents.

K0083

AUTHOR Bruner, A.

TITLE Immediate Dose-Rate Effects of 60Co on Performance and Blood Pressure in Monkeys

SOURCE Rad. Res. 70: 378-390, 1977

ABSTRACT Four groups of monkeys received 1000 rad of 60Co at 33, 50, 75, or 180 rad/min whole-body irradiation while performing a delayed matching-to-sample task. Systematic dose-rate effects were observed on performance and blood pressure within the initial 20 min postirradiation. The incidence and severity of performance decrement increased with higher dose rate. The incidence of performance decrement was 7, 33, 33, and 81%, respectively, for the 33, 50, 75, and 180 rad/min groups, including those animals showing early transient incapacitation. The appearance of postirradiation hypotension was systematically delayed and its rate of fall prolonged as dose rate was lower. The hypotension likewise appeared less deep with lower does rate. Based on the calculated cummulative dose absorbed at the type of symptom appearance, two coactive thresholds were proposed to exist: a total dose threshold of approximately 300 rad and a dose-rate threshold of about 25 rad/min, for the induction of the early hypotension-performance decrement syndrome. Performance decrement occurred only in the presence of hypotension, usually following its nadir by 1 to 4 min. Moreover, an increasing strength of association between depth of hypotension and frequency of decrement was demonstrated as the hypotension declined below 5% of baseline.

K0084

AUTHOR White, C. S.

TITLE Part II. Personnel Sensitivity. The Scope of Blast and Shock Biology and Problem Areas in Relating Physical and Biological Parameters

SOURCE Ann. NY Acad. of Science, 152(1): 89-102, October 28, 1968

ABSTRACT Following a brief introduction, the scope of blast biology has been outlined here. Included were: direct (primary) effects due to blast-induced variations in environmental pressure; indirect effects due to the impact of blast-energized missiles (secondary effects), indirect effects occurring as a consequence of whole-body displacement (tertiary effects), and other indirect effects included in a miscellaneous category.

Physically and biomedically oriented problem areas of concern to those who would formulate and utilize biomedical criteria for assessing blast hazards were identified and described.

On the physical side, these included uncertainties regarding the explosive source and free-field scaling: the attenuation and augmentation of physical parameters associated with geometric factors germane to various exposure conditions; physical interaction and the energy transfer associated with translational events encompassing animate as well as inanimate objects; and the contributions of positional and orientation factors. An understanding of appropriate combinations of the problem areas mentioned is essential to determine the environmental variation at locations of interest.

The biomedically oriented problem areas included; a search for the biologically significant physical parameters and their use to define "loading" forces quantitatively; the energy dissipation involved in biophysical interactions and the related etiologic mechanism at play; identification and quantization of critical biological responses among a variety of mammalian species; a variety of acute and chronic health problems concerned with diagnose, therapy, casualty care, rehabilitation and prophylactic measures and protective procedures; and finally the formation of biomedical criteria for assessing various levels of blast hazards along with their use and application in industrial safety, protective design and environmental health and control.

Attention was called to the lack of data required to interrelate quantitatively the physical and the biological factors outlined and the need was emphasized for collaboration among personnel trained in the physical and biological sciences to formulate refined biomedical criteria for assessing blast hazards in man and to apply the criteria properly to various conditions of exposure, either in the "open" or in a variety of above- and below-ground structures, be these either "open" or "closed."

Some of the characteristics of acceptable biomedical criteria were discussed. Tentative though incomplete criteria applicable to direct and indirect blast effects were presented in tabular form as examples of what has been useful in helping assess blast hazards and as a means of stimulating interested individuals to contribute ideas and data to update, improve and extend the criteria as well as to refine their application to blast-induced environmental variations of note occurring in any one of the wide spectrum of possible exposure conditions wherein man or equipment might be situated.

K0085

AUTHOR Richmond, D. R., Damon, E. G., Fletcher, E. R., Bowen, I. G., and White, C. S.

TITLE The Relationship Between Selected Blast-Wave Parameters and the Response of Mammals Exposed to Air Blast

SOURCE Ann.of the NY Acad. of Sciences, 152: 103-121, October 26, 1968

ABSTRACT

Summary: Shock tubes and high explosives were used to produce blast waves of various pressure-time patterns for studying their biological effects. Data obtained from these experiments show that, against a reflecting surface, the LD50 reflected pressure for any given species remained fairly constant at the "longer" durations and then rose sharply at the "shorter" times. For dogs and goats, "long" durations were beyond 20 msec and for mice, rats, guinea pigs, and rabbits, beyond 1 to 3 msec. At the "shorter" durations, response depends to a great extent on the impulse, and on peak pressure for the "longer" pulses. Higher reflected pressures can be withstood if animals are located beyond a certain distance from the reflecting surface where they receive the incident and reflected pressures in two steps, separated by a given time-interval. In free-stream exposures to air blast, orientation is significant. Animals suspended vertically or prone-side-on show a lower tolerance to blast waves of a given intensity or at a given range than those end-on because the dynamic pressure appears to add to their side-on pressure dose. Except for eardrum rupture and sinus hemorrhage, animals exhibit a remarkable tolerance to "slow"-rising blast pressures without the presence of shock fronts.

The lung may be considered the critical target organs in blast injuries. The release of air bubbles from disrupted alveoli of the lungs into the vascular system probably accounts for the rapid deaths. The degree of lung hemorrhage can be related to both the blast dose and the increase in lung weight over control values. For larger animals, the threshold for petechial hemorrhage was near 10 to 15 psi at "long" durations and 30 to 35 psi for pulses of 5 msec. At LD50 values, lung weights can be two to four times normal.

Ear injury has not been systematically studied; however, data gleaned from lethality and lung-injury experiments indicate that: eardrum response to blast pressures is subject to wide variation; a duration effect was observed in sheep, with 38 percent rupture recorded at 21.4 psi for durations near 100 msec versus no eardrum rupture at 32.4 psi when the durations were about 5 msec; and the severity of ear damage increases with the intensity of the blast.

From the presented data, tentative estimations of man's response to "fast"-rising pressures of 3-msec duration were compiled. Pressures for threshold and severe lung-hemorrhage levels were 30 to 40 and above 80 psi, respectively,. The threshold for lethality was 100 to 120 psi with an LD50 range of 130 to 180 psi. Time-honored estimates for human eardrum rupture values of and 15 psi, respectively for threshold and 50 percent could not be revised at this time.

The estimates for maximal effective pressures that may be received from the incident, incident plus dynamic or reflected pressure, depend chiefly on orientation. For an individual against a reflecting surface that is normal to the incident shock or prone with the charge detonated overhead, the maximal effective dose is the reflected pressure. If, however, the man is standing a few feet from this same reflecting surface or directly below the charge, he is subjected to pressures that rise in two steps; where, in the former position, the maximal effective pressure would probably be the incident plus the dynamic pressures in the firs step and, in the latter, only the side-on incident pressure in the initial step. The exact distance from a reflecting surface where the effective pressure changes from the reflected to incident or incident plus dynamic cannot be stated for man at this time. For personnel standing or prone-side-on to the charge when it is detonated at or near the surface, the side-on incident plug dynamic pressures become the effective pressure; however, with orientations end-on to this situation, only the side-on incident pressure appears to be the maximal effective pressure.

K0086

AUTHOR White, C. S., Bowen, I. G., and Richmond, D.R.

TITLE The Relationship Between Eardrum Failure and Blast-Induced Pressure Variations

SOURCE Space Life Sciences 2: 158-205, 1970

ABSTRACT During a series of field and laboratory experiments designed to study overall blast effects, incidental observations were made of the ears of more than 490 animals to determine eardrum failure associated with exposure to "atypical" and "typical" blast wave forms. Animals positioned inside structures were exposed to a variety of "atypical" blast waves, whereas those located inside shock tubes or in the open, when high explosives were detonated, were exposed to fairly "typical" waveforms. When the incidence of eardrum rupture is related to the various elements of the measured pressure-time curves, the association is not the same for the two types of wave shapes. Besides suggesting that tolerance is higher for "slow" that for "fast" rising wave forms, the findings demonstrate a wide variability in the magnitude of the overpressures required to rupture the eardrum. Within the limits of the data available, the quantitative differences are noted and discussed with emphasis on the apparent wide variability in tolerance and a proposed explanation for this finding. Although the results are limited strictly to the mammalian species studied, it is likely that the eardrum of man also is sensitive to the shape and character, as well as the magnitude and duration of the blast wave. The data are useful to military and civilian physicians, industrial otologists and all other health and safety personnel including those who have research interests in establishing quantitative dose-response criteria for individuals exposed to blast-induced variations in pressure.

K0087

AUTHOR Fletcher, E. R.

TITLE A Model to Simulate Thoracic Responses to Air Blast and to Impact

SOURCE In Symposium on Biodynamic Models and Their Applications, pp 27-70, Report No. AMRL-TR-71-9, Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, October 26-28, 1970

ABSTRACT A fluid-mechanical model of the thorax is described which has been useful in explaining biophysical mechanisms and scaling procedures applicable in assessing responses of the thorax energized by air-blast overpressures or by nonpenetrating missiles. Methods of parameter estimation are discussed. Comparisons are made between measured and computed intrathoracic pressures and chest-wall motions. The tested mammalian species are shown to divide into two approximately similar groups and the implications of this are discussed. Suggestions are made concerning possible future areas of research.

K0088

AUTHOR Hirsch, F. G. and Bruner, A.

TITLE Absence of Electromagnetic Pulse Effects on Monkeys and Dogs

SOURCE Presented at the 56th Annaul Meeting of Industrial Medical Association, Atlanta, GA, April 19-22, 1971

ABSTRACT

K0089

AUTHOR Damon, E. G., Yelverton, J. T., Luft, U. C., Mitchell, K. Jr., and Jones, R. K.

TITLE Acute Effects of Air Blast on Pulmonary Function in Dogs and Sheep

SOURCE Aerospace Med. 42(1): 1-9, 1971.

ABSTRACT Pulmonary function tests were conducted before and after exposure of animals to air blast produced in shock tubes or by high explosives. Pressure-time measurements were made with piezo-electric pressure transducers during each air blast exposure. Blood samples were obtained by arterial puncture, but most often from an indwelling arterial catheter. The blood PO2, PCO2, and pH and the endtidal and mixed expired CO2, O2, and N2 gas concentrations were measured for subjects breathing air and oxygen. There were increases in the alveolar-arterial O2 differences (A-a)O2, and venous admixture (Qs/Q) which generally correlated with the extent of blast-induced lung damage. Calculations indicated that most of the increase in (A-a)O2 for subjects breathing air could be attributed to the increase in Qs/Q alone. The threshold for lung injury resulting in increased venous admixture in sheep was about 20 psi for reflected "sharp"-rising overpressures of "long" duration. Pressures above 43 psi usually caused severe lung damage in which the venous-arterial shunt exceeded 30% of the cardiac output, a condition in which the arterial oxygen tension was below the level required for full saturation of the hemoglobin even with animals breathing pure oxygen.

K0090

AUTHOR Levy, W. J. and Richmond, D. R.

TITLE Air Blast Effects on the Eye

SOURCE Resume of exhibit displayed at the American Medical Association Convention, San Francisco, CA, June 1968

ABSTRACT

K0091

AUTHOR Holladay, A. and Bowen, I. G.

TITLE A Mathematical Model of the Lung for Studies of Mechanical Stress

SOURCE Proceedings of the San Diego Symposium for Biomedical Engineering, La Jolla, CA, 1963

ABSTRACT A mathematical model of the lung was conceived to simulate the fluid-mechanical response of the thoraco-abdominal structures under applied mechanical stresses. The stresses considered are explosive decompression and blast waves. In a preliminary study of decompressive effects on man, the air flow in the respiratory tract were simulated assuming that the thoracic and abdominal walls are perfectly rigid. The simulated pressures corresponded well with air pressures measured in a bottle subjected to an explosive decompression. The complete lung model, encompassing both air flow and changes in thoracic volume, was used in blast-wave studies. Good agreement was obtained between simulated and measured gaseous pressures in the thoracic cavity of animals exposed to both long- and short-duration blast waves in air. A model investigation was made of animal response to blast waves rising to peak overpressure in two steps; the peak gaseous pressure in the simulated lung was sharply reduced as the duration of the initial step was increased fractions of a millisecond. This reduction was caused primarily by an increase in the level of pulmonary pressure due to the initial blast step, which in turn restrained further compression of the simulated lung by the second step. The restraining influence of pulmonary pressure level was discussed in relation to animal tolerance to blast. To help explain certain mortality trends a theoretical relation was derived between animal body mass and simulated pulmonary response to applied blast waves of constant amplitude: the lung pressure responses of animals of all body masses are the same in magnitude, but differ in response time according to the cube root of body mass.

K0092

AUTHOR White, C. S., and Richmond, D. R.

TITLE Blast Biology

SOURCE Clinical Cardiopulmonary Physiology, Chapter 63, pp 974-992, Grune & Stratton, Inc., 1960

ABSTRACT By permission of the Atomic Energy Commission this chapter was summarized from document TID 5764 and the reader is referred to this reference for the full text, along with quantitative animal data and their relation to nuclear explosives.

K0093

AUTHOR Yelverton, J. T.

TITLE Pathology Scoring System for Blast Injuries

SOURCE J of Trauma: Injury, Infection, and Clinical Care, 40 (3): S111-S115, 1996. Presented at the 7th International Symposium of Weapons Traumatology and Wound Ballistics, St Petersburg, Russia, September 1994.

ABSTRACT A pathology scoring system, initially developed by the Walter Reed Army Institute of Research in collaboration with the Lovelace Biomedical and Environmental Research Institute and currently used in the Jaycor Pathos data base program, was modified to arrive at a severity of injury index for individual animals. With this approach, n animal was assessed for injuries by using an alphanumeric code. External lesions, fractures, and trauma to pharynx/larynx, trachea, lungs, heart, hollow abdominal organs, and solid abdominal organs were assigned individual numerical scores based on the severity of the lesion. The various lesions also were graded as trace, slight, moderate, or extensive, depending upon their severity. Each individual score was divided by its preassigned maximum possible score to arrive at a severity of injury ratio for the organ or system. The presence or absence, and the extent of pneumothorax, hemothorax, hemoperitoneum, coronary air, or cerebral air were summed and added to the sum of the ratios. The resulting value was then multiplied by 1 or 2 depending upon whether the subject was a survivor or a fatality, to arrive at an adjusted severity of injury index by excluding ear damage values from the sum of the ratios. The severity of injury index was used in conjunction with a single degree of freedom blast model to develop damage risk criteria for blast injury.

K0094

AUTHOR Axelsson, H., and Yelverton, J. T.

TITLE Chest Wall Velocity as a Predictor of Nonauditory Blast Injury in a Complex Wave Environment

SOURCE J. of Trauma: Injury, Infection, and Clinical Care, 40 (3): S31 to S37, 1996

ABSTRACT Previous blast injury prediction criteria have been based on exposure to classic Friedlander or ideal blast waves. An ideal waveform is characterized by an instantaneous rise to a peak overpressure that decays exponentially to ambient pressure followed by a negative phase. The prediction criteria did not address injuries resulting from exposure to complex blast waves. It was difficult to establish a simple relationship between the two because complex blast waves typically consist of multiple shocks with variable frequency content and intensity that may be superimposed on a slow rising quasistatic pressure pulse. This paper deals with the application of a single degree of freedom mathematical model, originally developed to measure the response of the thorax to Friedlander waves, to calculate chest wall velocities resulting from various complex blast loads. Experimental results with sheep, exposed to complex blast waves in enclosures, demonstrated that there was a good relationship between the Adjusted Severity of Injury Index (which includes injury to the lungs, upper respiratory tract, gastrointestinal tract and solid intraabdominal organs) and the calculated peak inward chest wall velocity. In addition, there was a good correlation between these results and previously established Friedlander injury prediction curves. The velocity of complex blast waves was nearly the same as that of Friedlander waves for a given degree of injury: 3-4.5-meters/second for threshold injury, 8-12 meters/second for an LD1, and 12-17 meters/second for an LD50.

K0095

AUTHOR Jones, R. K., Chiffelle, T.L., and Richmond, D.R.

TITLE A Study of Effects of Combined Blast and Radiation Injury in Sheep

SOURCE In Intermedes Proceedings, Combined Injuries and Shock, pp 57-66, 1968.

ABSTRACT Summary: Sheep were exposed to either burst type neutron-gamma irradiation, short duration high explosive blast, or a combination of both administered on the same day. Total lethality was synergistically greater in animals exposed to the combined injury than was observed when each stress was given singly. The superimposition of radiation-induced granulocytopenia on blast produced pulmonary injury resulted in the development of neutropenic pneumonia and appeared to be responsible for enhanced lethality. Hemopoietic parameters were followed in all groups, and prognosis prediction based on the usual platelet and white blood cell depression was found to be misleading in sheep exposed to combined radiation and blast.

K0096

AUTHOR Yelverton, J. T., Henderson, E. A., and Dougherty, R. W.

TITLE A Chronically Implanted Arterial Catheter for Unanesthetized Animals

SOURCE The Cornell Veterinarian, Vol. LIX(3): 466-472, July 1969

ABSTRACT Summary: Arterial blood sampling and pressure recording in unanesthetized sheep were accomplished with the use of chronically implanted catheters. A short length of vinyl tubing was inserted through the femoral artery into the abdominal aorta to a point anterior to the aortic-iliac bifurcation but posterior to the renal arteries. The free end of the tube was then passed subcutaneously around the body to the back, brought through the skin near the middorsal line, and fitted with a Luer-Lock stopcock. Catheters have remained functional by this technic for periods ranging from 7 to 142 days.

K0097

AUTHOR Richmond, D. R., Fletcher, E. R., Yelverton, J. T., and Phillips, Y. Y.

TITLE Physical Correlates of Eardrum Rupture

SOURCE Annals of Otology, Rhinology & Laryngology, 98(5), Part 2, Suppl. 140: 35-41, May 1989

ABSTRACT Eardrum (tympanic membrane) rupture in humans and animals in relation to various blast pressure-time patterns was reviewed. There were few systematic studies on eardrum rupture as a consequence of blast overpressure. Most reports did not describe the area of the eardrum destroyed. The peak overpressures required to produce a 50% incidence of eardrum rupture (P50) were summarized. Most of the animal data pertained to dogs. The highest P50 for dogs, 296 kPa, was associated with smooth-rising overpressure. For complex wave patterns occurring inside open shelters subjected to nuclear blasts, the P50 was 205 kPa. For fast rising blasts in a shock tube it was 78 kPa, and 105 kPa for statically applied pressures. The duration of the overpressure was not a factor unless it was very short. The influence of the orientation of the head to the oncoming blast was demonstrated. An ear facing the blast may receive reflected overpressures several times that for one side-on to the blast. An ear on the downstream side of the head was exposed to about the same overpressure as the side-on ear. A P50 for humans of 100 kPa and a threshold of 35 kPa has been used widely in blast criteria. A recent study suggests a threshold (P1) of about 20 kPa, and gives the overpressures required to produce minor, moderate, and major eardrum ruptures. These data were presented in the form of curves showing the overpressures as a function of duration required to inflict a P1 and a P50 of eardrum rupture of the three levels of severity.

K0098

AUTHOR Bruner, A., Neely, A.W., Henderson, E. A., and Weiss, G.K.

TITLE Effects of 1000 Rad of 60Co on Baroreceptor Reflex Responses in Phenylephrine and Carotid Occlusion in Monkeys

SOURCE Radiat. Res. 61:393-404, 1975

ABSTRACT Failure of the baroreceptor reflex mechanisms has been proposed as a basis for the early hypotension seen in monkeys after high-dose, whole-body irradiation. The present work involved the testing of baroreflex sensitivity by carotid occlusion and phenylephrine injection before and after 1000 rads 60Co in nine unanesthetized, restrained monkeys. During the early postradiation minutes, at the time of deepest hypotension, both of the baroreflex tests revealed depressed baroreflex sensitivity (diminished blood pressure and heart rate responses). After 8-15 min postirradiation, the phenylephrine, but not the occlusion, test demonstrated a reversal to significant baroreflex hypersensitivity which persisted 24 hr or more. Early shifts in the level relation between blood pressure and heart rate also occurred after irradiation. No failure of the baroreflex mechanisms was evident, in contradiction to a previous finding.

K0099

AUTHOR Bruner, A., Bogo, V., and Jones, R. K.

TITLE Delayed Match-to-Sample Early Performance Decrement in Monkeys after 6Co Irradiation

SOURCE Rad. Res. 63: 83-96, 1975

ABSTRACT Sixteen monkeys were trained on a delayed match-to-sample task (DMTS) based on shock avoidance and irradiated with single, whole-body exposures of from 396 to 2000 rad 60Co (midbody dose) at between 163 and 233 rad/min. Pre- to post-irradiation performance changes were assessed using a penalty-scaling measure which differentially weighted incorrect responses, response omissions, and error-omission sequences. Thirteen of the animals displayed early performance decrement, including five incapacitations, at lower doses (<1000 rad) than heretofore found effective. This was considered a function of task complexity, measurement sensitivity, and gamma effectiveness. The minimum effective midbody dose for inducing decrement using the DMTS task was estimated to be on the order of 500 rad. The nature of early, transient performance decrement seems to reflect more of an inability to perform than an inability to perform correctly.

K0100

AUTHOR Bruner, A., Bogo, V. and Gallegos, A.

TITLE Picture Memory (Pseudomatching) in Rhesus Monkeys

SOURCE Perceptual and Motor Skills 42: 627-633, 1976

ABSTRACT Pseudomatching, the selection of the correct comparison stimulus without dependence on presentation of a sample stimulus, was demonstrated in monkeys being trained ostensibly on a matching-to-sample, shock-avoidance task. Pseudomatching occurred whenever the problem sets were not fully counterbalanced for key position and correct symbol and seemed to represent memorization of specific stimulus configurations. Some animals showed the capacity to memorize hundreds of different 4-choice problems as indicated by test trials on which the samples were omitted. To prevent pseudomatching contamination of matching-to-sample behavior one must arrange full counterbalancing and randomization of stimuli and reinforcements. Pseudomatching test trials are also recommended.

K0101

AUTHOR Hirsch, F. G.

TITLE Effects of Overpressure on the Ear--A Review

SOURCE Annals of the NY Acad. of Sci. 152, Article 1: 147-162, October 28, 1968

ABSTRACT

K0102

AUTHOR Richmond, D. R., Bowen, I. G., and White, C.S.

TITLE Tertiary Blast Effects. Effects of Impact on Mice, Rats, Guinea Pigs and Rabbits

SOURCE Aerospace Med. 32: 789-805, September 1961

ABSTRACT 1. A total of 455 animals including 113 mice, 178 rats, 111 guinea pigs and 54 rabbits were subjected to impact at velocities ranging between 25 feet per second and 51 feet per second.
2. The desired impact velocities were generated by allowing the animals to free-fall from various heights to a flat concrete pad. The ventral surface of each animal was the area of impact.
3. The velocities at impact were determined by from equations that were empirically derived and from high speed photographic records of the animal.
4. Probit analyses of the 24-hour mortality data yielded LD50 values with 95 per cent confidence limits as follows: mouse, 39.4 feet per second (37.4-42.0); rat, 43.5 feet per second (42.0-44.8); guinea pig, 31.0 feet per second (30.0-31.9); and rabbits, 31.7 feet per second (30.2-33.3).
5. Of the 200 animals killed by impact, 149 (75 per cent) died within 20 minutes and 90 per cent within one hour. Only 10 per cent of the deaths occurred between the 2-hour and 24-hour period. The general trend was for the larger species to have the longer survival times.
6. From an interspecies extrapolation the LD50 impact velocity for a 70 kilogram animal was calculated to be 26 feet per second (18 miles per hour).
7. From the probit mortality curve derived for a 70 kilogram animal, the predicted threshold condition for lethality was calculated to be 21 feet per second (14 miles per hour).
8. The results from the present study were discussed relevant to the information available in the literature on the effects of ground shock on personnel in underground structures, deck heave, translation caused by air blast, automobile accidents, falls, and related decelerative phenomena.
9. The minimum impact velocity required for skull fracture was pointed out to be near 13.5 feet per second (9.2 miles per hour). (Gurdjian et al).
10. The "initial velocity" threshold for fracture of the heel bone of standing objects was between 11 and 16 feet per second (Black et al; Draeger et al).
11. The maximal impact velocity tolerated by human subjects, dropped in a seated position, was reported to be about 10 feet per second (Swearingen et al).
12. Human fatalities in automobile statistics showed 50 per cent mortality at vehicular speeds near 33.8 feet per second (23 miles per hour) which was in fair agreement with 50 per cent impact velocity (26 feet per second) obtained in the present study for an animal of comparable body weight (from DeHaven).
13. It was tentatively concluded that 10 feet per second (7 miles per hour) was the "on-the average safe" impact for adult humans.

K0103

AUTHOR Richmond, D.R., Jones, R.K., and White, C. S.

TITLE The Effects of Blast and Ionizing Radiation in Rats

SOURCE Intermedes Proceedings, Combined Injuries and Shock, pp 67-74, 1968

ABSTRACT Summary: The effects of whole-body X-irradiation, air blast, and combinations of X-irradiation and air blast upon lethality and survival times were studied in rats. One group was given a near LD50/30-day level of 250kvp X-rays; the second group, an LD5/30-day dose of air blast; the third group, radiation and blast on the same day; and the fourth group, radiation followed by blast six days later. A additional group of rats served as controls. In terms of 30-day lethality and number of early and delayed deaths, a possible synergistic effect was noted in the animals that were blasted seven days following radiation. The 30-day lethality for those irradiated and blasted on the same day was simply additive. The results are discussed and compared with previous investigations involving the effects of whole-body radiation and blast in mice.

K0104

AUTHOR Young, A. J., Jaeger, J. J., Phillips, Y. Y., Yelverton, J.T., and Richmond, D. R.

TITLE The Influence of Clothing on Human Intrathoracic Pressure During Airblast

SOURCE Aviat. Space Environ. Med., 56: 49-53, 1985

ABSTRACT Exposure to airblast can result in injury to the lungs and other gas-containing organs. The mechanism of lung injury is not clearly understood, but may be related to rapid increase in intathoracic pressure (ITP) which is produced when the blast wave strikes the chest wall. The purpose of this study was to determine if ITP during airblast would be influenced by several different types of protective clothing. Ten healthy young male volunteers were exposed to airblast while standing face-on and wearing (2) military fatiques (control condition); (2) fatigues with field jacket; (3) fatigues with ballistic armor vest; (4) fatigues with ceramic vest; (5) fatigues with ceramic vest over the ballistic vest. The incident blast waves simulated artillery muzzle blast. In each subject, an esophageal strain-gauge pressure transducer measured ITP during the blast. The pressure signal was analyzed for ITPmax and maximum rate of ITP (dP.dt max-1). In addition, the power density spectra of each ITP wave was computed and the peak frequence (fp) and centroid frequency (fc) were calculated. When the subjects wore the ballistic vest, the mean ITPmax was higher ($p < 0.05$) than when they were exposed to airblast in fatigues alone. ITPmax was not influenced by the other clothing ensembles. The mean dP.dtmax-1 was significantly different with any protective clothing ensemble. Clothing had no significant effect of fp, but with the ballistic vest, the mean calculated fc was higher ($p < 0.05$) than that for the fatigues alone. These results indicate that the types of protective clothing studied do not reduce the intrathoracic pressure response of humans exposed to low-level airblast, and therefore may not offer protection against airblast lung injury.

K0105

AUTHOR Dodd, K. T., Yelverton, J.T., Richmond, D. R., Morris, J. R., and Ripple, G. R.

TITLE Nonauditory Injury Threshold for Repeated Intense Freefield Impulse Noise

SOURCE J. of Occup. Med. 32(3): 260-266, March 1990

ABSTRACT Exposure to impulse noise is an important occupational health concern. The risk of injury to auditory structures is well recognized and provides the cornerstone for present safety standards. For freefield impulse noise nonauditory injury is dependent on peak pressure, positive phase duration (or impulse), and number of exposures. Trivial laryngeal petechiae are shown to precede nonauditory injury to more critical organs (i.e., pulmonary and gastrointestinal systems). This study identified the critical impulse noise thresholds causing trivial laryngeal petechial changes resulting from exposure to 5, 25, and 100 repetitions of specific levels of impulse noise. Because of anatomical differences, sheep should be slightly more susceptible to impulse noise laryngeal petechial changes than man; therefore, it seems reasonable to set the absolute limits for nonoccupational exposure levels below those causing laryngeal petechiae in sheep for persons wearing adequate hearing protection. This study does not address human auditory injury that may occur above or below these exposure limits even with proper hearing protection.

K0106

AUTHOR Bowen, I. G., Fletcher, E. R., Richmond, D. R., Hirsch, F. G., and White, C. S.

TITLE Biophysical Mechanisms and Scaling Procedures Applicable in Assessing Responses of the Thorax Energized by Air-Blast Overpressures or by Nonpenetrating Missiles

SOURCE Annals of the NY Acad. Of Sci. 152, Article 1, pp 122-146, October 28, 1968

ABSTRACT A mathematical model was devised to study the principal biophysical mechanisms of the thorax subjected to air blast or to nonpenetrating missile impact with a chest wall. The salient features of the model were described and results of a dimensional analysis of the model parameters were presented. The dimensional analysis, based on similarity of mammalian species, resulted in scaling equations relating for a given biological response of the parameters of similar blast waves (e.g., maximum overpressure and duration of the wave) to the body mass of similar mammals and to the ambient pressure. The scaling relations were interpreted for high-explosive blast waves, making use of the usual scaling equation for explosives. Also, the analysis was extended t include nonpenetrating missile impact with the chest--relating the mass and impact area of the missile to body mass, and the impact velocity to ambient pressure. Estimated parameters were used in the model to simulate a blast experiment in which a dog was placed at the end-plate of a shock tube. Computed intrathoracic overpressures showed reasonable agreement with those measured. A sensitivity study indicate that computed lung pressures decrease with increases in the magnitudes of the damping factors, lung volumes, orifice areas, and spring constants (listed in the order of importance). Increases in the masses and areas of the pistons representing the chest walls, however, result in higher computed lung pressures. These results were compared to intrathoracic pressures computed for various blast waves producing different levels of morality.

Intrathoracic pressures wee computed for dogs exposed broadside to "long"- and "short"-duration blast waves. Experimental results for guinea pigs were used to help evaluate the results obtained for the "long"-duration wave. Experimental data were used to show that approximately equivalent mortality responses were obtained for mice, rats, guinea pigs, and rabbits exposed to step loads of constant magnitude if the time between the incident and reflected shocks was proportional to the cube root of body mass.

High explosive data were used to establish the 50 percent mortality the relationship between (height of burst)/(body mass) 1/3 and (mass of explosive charge)/(body mass). It was found that two relationships exist, one for small animals (mice, rats, guinea pigs, and rabbits) and the other for larger animals (monkeys, dogs, goats, sheep, and swine). Possible differences in the two groups of species were discussed in terms terms of published physiological data.

A general analysis was presented of pressure-duration data obtained by exposing experimental animals against reflecting surfaces to blast waves generated by high explosives and shock tubes. The analysis showed approximately similar responses within each to two groups of species; (1) mouse, hamster, rat, guinea pig, and rabbit; (2) cat, monkey, dog, goat, sheep, cattle, and swine. An equation was derived for each group giving 50 percent lethal overpressure as a function of wave duration, ambient pressure, and body mass of the mammal.

Further analyses showed that the blast waves producing 50 percent mortality have two approximately invarient parameters for a given body mass and ambient pressure; viz., partial impulse occurring within a characteristic time. These parameters were evaluated for each of the groups previously mentioned and the appropriate scaling functions indicated. The characteristic time was related to the time during which the most significant animal response occurs--maximum compression of the thorax.

Using appropriate scaling procedures, the analyses mentioned above were made applicable to 70-kg mammals and 14.7-psi ambient pressure. The resulting blast tolerances were compared to those previously estimated for man.

Experiments were described in which the rib cage of dogs was struck by nonpenetrating missiles near the mid-lateral point of the thorax. Photographic data were used to make time-displacement analysis for the missile. The results were compared with those computed with the model, and various biophysical mechanisms were discussed.

Results obtained form 45 nonpenetrating missile experiments were presented in tabular form. Lung mass data were plotted to show that the lung on the side receiving the impact sowed the greatest response to the impact but that significant bilateral response occurred for the more damaging impacts.

A general analysis of the nonpenetrating missile data resulted in an equation described the empirical relationship between (1) lung mass normalized to body mass, (2) impact velocity o the missile, and (3) missile mass normalized to body mass. It was found that peak intrathoracid pressures computed with the model were approximately constant for the experimental conditions producing constant normalized lung masses.

K0107

AUTHOR White, C. S., Bowen, I. G., and Richmond, D. R.

TITLE A Comparative Analysis of Some of the Immediate Environmental Effects at Hiroshima and Nagasaki

SOURCE Health Physics, Pergamon Press, 10: 89-150, 1964

ABSTRACT The problem areas of concern to those who would establish a quantitative relation between biologic response and the more immediate environmental variations caused by nuclear explosions were defined. The scope of blast and shock biology was set forth and a selective summary of current knowledge regarding biological blast effects was presented. Tentative criteria useful in assessing the hazards of some of the major nuclear effects were noted. Following elucidation of the range-yield-effects relationship applicable to high-yield explosions generally, the criteria were applied specifically to a 20-k ton yield burst at heights assumed to apply to the Hiroshima and Nagasaki explosions. The procedure, establishing the range-effect relationships for the two Japanese cities, was carried out through use of the freefield scaling laws and a mathematical model allowing scaling of translational effects for both debris and man. Thus an attempt was made to predict the ranges inside which the potential existed for producing specified levels of biological damage. For each of the predicted ranges values for overpressure, thermal and initial nuclear radiations along with translational velocities for man and glass fragments were computed to allow a more balanced appreciation of all the effects parameters that pose a hazard to man. The implications of the free-field range-effects data in interpreting some of the immediate effects at Hiroshima and Nagasaki were explored and discussed. Though the overall analytical approach followed as thought to be useful and sound, the tentative nature of many of the numerical data presented was emphasized. Thus those numbers employed representing blast current estimates as well as values arbitrarily assigned were all noted to be subject to future refinement as new information expands the understanding of nuclear phenomenology and the consequences of exposure thereto.

K0108

AUTHOR Richmond, D. R.

TITLE Threshold for Laryngeal Lesions from Repeated Blasts - A Progress Report

SOURCE Progress Report, Lovelace Biomedical and Environmental Research Institute, prepared for Department of the Army, Walter Reed Army Institute of Research, Washington, D.C., June 23, 1980

ABSTRACT The present experiments were conducted to determine the incidence of severity of laryngeal injury in sheep subjected to repeated blasts at levels, numbers, and rates pertinent to the muzzle blasts likely to be generated by modern artillery; specifically, 2.5 and 5 psi, delivered 50 and 100 times at a rate of 1 per minute. There was a slight increase in the incidence of laryngeal lesions when the number of blasts was increased from 50 to 100; the severity of these very minor lesions did not grow importantly with the greater number of blasts.

K0109

AUTHOR Yelverton, J. T

TITLE Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals

SOURCE Lovelace Biomedical and Environmental Research Institute, presented at The 102nd Meeting of the Acoustical Society of America, Carillon Hotel, 30-Nov-4 Dec 1981, Miami Beach, FL, 1981

ABSTRACT In 1969 an underwater test facility was constructed specifically to study the biological effects produced by underwater blast. Investigations were conducted to determine the ranges from explosive charges up to 3.6 kg that were safe, damaging, or lethal to selected species of fish, birds, and mammals. It was established that the impulse (integral of p.dt) in the underwater blast wave was the parameter that governed biological damage and not peak overpressure or energy. There was good correlation between the impulse for 50-percent mortality and body mass in fish that ranged from 12 Pa.sec for 002-g guppy fry to 340 Pa.sec for 740-g carp. The blast response was the same in fish having either ducted or nonducted swim bladders. Mallard ducks were selected as a model to represent birds on and beneath the water's surface. Impulse levels that were safe, injurious, or lethal to birds were determined and presented as a function of range and charge mass. The tolerance of six mammalian species, ranging in body mass from 0.2 to 45 kg, was investigated. A tentative interspecies extrapolation, relating impulse to body mass, was illustrated as a method that may be pursued to predict the response of large marine mammals to underwater blast. A safe-impulse criterion of 14 Pa.sec for personnel was evaluated by an unprotected swimmer in a variety of charge-depth configurations.

K0110

AUTHOR Yelverton, J. T., Richmond, D. R., and Fletcher, E. R.

TITLE Bioeffects of Simulated Muzzle Blasts

SOURCE Progress Report, Lovelace Biomedical and Environmental Research Institute, prepared for Department of the Army, Walter Reed Army Institute of Research, Washington, D.C. (no date)

ABSTRACT The muzzle blast pressure-time patterns recorded at the crew positions of a 155-mm howitzer and an 82-mm mortar were simulated for assessing non-auditory blast injuries. The most intense pressure-time patterns associated with the howitzer had peak pressures of 20 kPa, durations of 4-8 msec, and positive impulses of 25-55 kPa.msec. These waveforms were simulated beyond the open end of a shocktube driven by high explosives. Primacord charges, in a circular coil, were held in frames that were inserted in the top of the shocktube. Each charge had its detonator and firing line attached to facilitate rapid firing--100 blasts at a rate of 1 per minute. Thirty-three percent of the animal models given 18 kPa 50 times sustained a few petechial hemorrhages in the lining of the upper respiratory tract. There were no other blast lesions detected in the lungs or gastrointestinal tracts of these animals.
The muzzle blast measured 0.5 m from the 81-mm mortar selected for study had a peak overpressure of near 40 kPa, a duration of slightly less than 1 msec, and an impulse of 12.8 kPa.msec. This waveform was simulated 0.5 m from a 105-cm long vertical shocktube of 36 cm I.D. The charge consisted of a 2.29-cm length of primacord folded into a 3.8x18-cm wad that was detonated 36 cm into the tube. Nine tests were conducted each involved exposing four large animals to 300 consecutive blasts at a rate of just over 2 per minute. There were no gross non-auditory blast injuries detected in any of the 36 test specimens.
This paper will also present and discuss damage-risk criteria for personnel exposed to 1 or 20 blasts in the short-duration range.

K0111

AUTHOR Young, A. J., Jaeger, J. J., Phillips, Y. Y., and Richmond, D. R.

TITLE Exposure of an Anthropomorphic Dummy to Blast Overpressure

SOURCE Walter Reed Army Institute of Research, Division of Medicine, Department of Clinical Physiology, Washington, DC (no date)

ABSTRACT This presentation will report the use of an anthropomorphic dummy as a model for human responses to blast overpressure. The results of pilot studies investigating the effects of body orientation and protective clothing on intrathoracic pressure changes during blast exposure will be discussed.

K0112

AUTHOR Jaeger, J., Phillips, Y., Young, A., Hoyt, R., and Richmond, D. R.

TITLE Low Level Blast Exposure in Humans

SOURCE Walter Reed Army Institute of Research, Department of Clinical Physiology, Division of Medicine, Washington, DC

ABSTRACT Volunteers were active duty military males. Ten subjects participated in this study. Individuals had a chest roentgenogram free of evidence of cystic or bullous disease within 2 years of the study. Individuals were free of acute respiratory or gastrointestinal symptoms for at least 2 weeks prior to the study. Measurement of height, weight and chest anterior-posterior and transverse diameters were made. Within 24 hours of exposure an audiogram was performed. Hearing protection consisted of EAR plugs, with visual inspection of insertion, and ear muffs. After the final exposure of the day, the audiogram was repeated.
Objectives: 1. To observe the effects of blast orientation, arm position and clothing on the measured pressure-time histories. 2. To compare observed ITP to the predicted ITP response from computer models and from the Swedish anthropomorphic dummy. 3. To verify data on the resonant qualities of human systems.

K0113

AUTHOR Yelverton, J. T., Hicks, W., and Dodd, K. T.

TITLE Biological Response to Complex Waves

SOURCE Results Report, Los Alamos National Laboratory, prepared for Department of Respiratory Research, Division of Medicine, Walter Reed Army Institute of Research, Washington, D.C., March 1988

ABSTRACT Objectives: The objectives of this study were: 1. To determine the blast effects produced in sheep by complex blast waves generated in a 10x8x8-ft enclosure. 2. To record complex wave loading parameters around a cylinder for input to an injury model.

K0114

AUTHOR Phillips, Y. Y., Mundie, T. G., Yelverton, J. T., and Richmond, D. R.

TITLE Cloth Ballistic Vest Alters Response to Blast

SOURCE Department of Respiratory Research, Walter Reed Army Institute of Research, Washington, D.C. In Proceedings Fifth International Symposium, 11-14 June 1985, Gotenburg, Sweden. Also J. of Trauma 28(1): S149-

ABSTRACT Ballistic wounds have been and will remain the principal cause of casualties in combat. Cloth ballistic vests (CBV) play an important role in limiting critical wounds from fragments and small-arms fire. There is an increased risk of primary blast injury on the modern battlefield. In a previous study, volunteers were exposed to short-duration blast waves of low peak pressure (18.6 plus or minus 0.8 kPa). Pressure measurements made in the distal esophagus as an estimate of intrathoracic pressure (ITP) were significantly higher ($p<0.05$) when the standard U.S. Army ballistic jacket was worn (8.7 plus or minus 1.2 kPa) than when fatigues alone were worn (7.4 plus or minus 0.7 kPa). In this study 58 sheep were exposed to nominal blast levels of 115, 230, 295, and 420 kPa peak pressure in groups of 12, 18, 16, and 12, respectively. Half of each group was fitted with a CBV. Lung weight index (LWI), lung weight expressed as a percentage of body weight, was used as a measure of blast injury. Use of the CBV was associated with a significant increase in LWI ($p <0.05$) which averaged 21% for the two middle exposure groups. At the 420 kPa level, two of six non-CBV animals died as opposed to five of six animals wearing the CBV. Intrathoracic pressure was generally higher in the CBV group. Likely mechanisms of injury enhancement include an increase in target surface area and an alteration of the effective loading function on the thorax. This information may be useful in the triage and treatment of casualties exposed to intense blast environments.

K0115

AUTHOR Axelsson, Hakan and Richmond, D. R.

TITLE The Non-Auditory Effects of Complex Blast Waves on Personnel Inside an APC Attacked by Shaped Charge Warheads

SOURCE Swedish Defence Research Establishment, FOA rapport, presented at the Sixth International Symposium on Wound Ballistics, 1-4 November 1988, Chongqing, People's Republic of China

ABSTRACT By using a mathematical model of the human thorax and measured pressure-time histories inside an armored vehicle attacked by shaped charge warheads it has been shown that the computed intrathoracic pressures and chest wall velocities are twice as high in the back as in the front of the vehicle. This has been attributed to the linear dimensions of the inside of the compartment giving different resonance frequencies and consequently different response of the thorax to the complex blast wave load.

K0116

AUTHOR Young, A. J., Hoyt, R.F., Jaeger, J. J., and Phillips, Y. Y.

TITLE Short-Duration Airblast Exposure Does Not Increase Pulmonary Microvascular Permeability

SOURCE Military Medicine, 151(3): 139, 1986

ABSTRACT The estimated threshold for lung injury in man exposed to a single short-duration airblast (AB) is 103-138 kPa over ambient pressure. The estimate was based on observations of petechiae on the lung surface of animals exposed to this AB intensity. The present investigation was designed to determine if lung microvascular permeability was increased by exposure to AB of this intensity. Systemic and pulmonary arterial and left atrial (Pla) pressures, lung lymph flow rate, lymph/plasma protein ration, and lymph protein clearance rate were measured during baseline period (B) and during 3 hr or artificially increased Pla in 5 control and 8 experimental sheep. The experimental group was studied 1 hour after they had been exposed to AB having peak pressure of 140 plus or minus 1 kPa and a duration of 14.3 plus or minus 0.1 msec. Vascular pressures, lung lymph flow rate, lymph/plasma protein ratio, and clearance rate during B were equal in I and II. There were no differences between I and II in any vascular pressure response to increased Pla. For I, lung lymph flow rate became higher than B after 60 min of increased Pla. However, lung lymph flow rate in II became significantly higher than B only after 90 min of increased Pla. Lymph/plasma protein ratio fell during increased Pla with no difference between I and II. There were no differences between I and II in lymph protein clearance rate which remained unchanged with increased Pla. Apparently, lung microvascular permeability in AB exposed animals was not increased.

K0117

AUTHOR Richmond, D. R., Yelverton, J. T., Fletcher, E. R., and Hicks, W.

TITLE The Biological Effects of Plexiglas Fragments

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, prepared for Ballistic Research Laboratories, Aberdeen Proving Ground, MD, 1 Jan 1974

ABSTRACT The wounding potential of plexiglas fragments was studied using anesthetized sheep. The fragments, carried in Styrofoam sabots, were propelled from an air gun. The fragment velocities were measured by an electronic counter at the end of the barrel. Fragments of 0.125-inch-thick stretched plexiglas weighing 1, 10, 50, and 100 g were fired point-on at the thorax and abdomen areas. In addition, 10-g fragments were fired at the skull and neck regions. A limited number of tests were run t get some idea of the effects of fragment orientation at impact, fragments of 0.077 and 0.25 inch thicknesses, nonstretched plexiglas fragments, and the effects of cloth over the neck and abdomen target areas. The lesions produced by the fragments resembled those described from stab wounds. There was little collateral damage at the velocities employed. Probit analysis run on the results related percent skin penetration and percent body wall penetration with impact velocities. Velocities for fragments to penetrate the skin over the trunk 50-percent of the time ranged from 92 ft/sec for the 1-g fragments to 32 ft/sec for the 100-g fragments. The results of this study indicated that some fragments inside the UH-1 helicopters side-on to the blast at 1.2 and 2.3 psi over pressure levels had sufficient mass and velocity to penetrate the body wall of sheep. In the aircraft at higher overpressure levels, there were larger numbers of potentially damaging fragments. Nearly all the fragments trapped inside the helicopters had sufficient mass and velocity to lacerate or penetrate the skin.

K0118

AUTHOR White, C. S.

TITLE Project Harbor Study: Notes on Immediate Survival 1. Biomedical Parameters

SOURCE Project Report, Project Harbor Study, National Academy of Sciences, Woods Hole, Massachusetts, Team C, Lovelace Foundation for Medical Education and Research, prepared for Division of Biology and Medicine, U. S. Atomic Energy Commission, August 1963

ABSTRACT Introduction: There are clearly a number of interrelated physical and biomedical parameters that are relevant to planning measures for enhancing immediate and early survival following a nuclear attack. Among them are a definition of the problem areas involved, tentative biological criteria for specified levels of human response to the major effects phenomena associated with nuclear explosions, and a few general and specific matters of significance. The purpose of this communication is to summarize selected appropriate data and thinking as briefly as possible, citing original sources for those who wish to explore facets of the presentation in more detail.

K0119

AUTHOR Bowen, I. G., Richmond, D. R., and White, C. S.

TITLE Translational Effects of Blast Waves: A review of past work and suggestions for future experiments with 500-ton high-explosive shot

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, D.C., March 11, 1963

ABSTRACT Introduction: The Lovelace Foundation has conducted experiments on two operations at the Nevada Test Site to evaluate the translational effects of nuclear-produced blast waves. Experiments were performed on five shots having yields from 11 to 44 kt. Translational velocities were determined for about 20,000 objects such as stones, spheres, window-glass fragments, steel fragments, and anthropomorphic dummies.
Theoretical studies and laboratory experiments were made to help explain the mechanisms involved in the translation of objects by blast waves and to make it possible to predict their behavior when exposed to any specified classical blast wave.
This report will (1) discuss the phenomena considered in the theoretical study of the behavior of secondary missiles as a function of blast-wave parameters, (2) describe the experimental techniques used in the field studies, (3) compare some of the experimental results with those predicted, and (4) present a few proposed experiments for the 500-ton shot to be detonated in 1964 at the Suffield Experimental Station.

K0120

AUTHOR Fletcher, E. R.

TITLE Blast Effects on Helicopter Plexiglas Windows

SOURCE Contract Report No. 142, Lovelace Foundation for Medical Education and Research, prepared for U. S. Army Ballistic Research Laboratories, Aberdeen Proving Ground, MD, March 1974

ABSTRACT Styrofoam witness plates and cameras were used to obtain information about the flying plexiglas fragments inside ten UH-1 helicopters in the vicinity of a 500-ton TNT detonation. The aircraft were oriented side-on and head-on in open terrain and side-on in revetments at ranges where the peak incident overpressures were 1.2, 2.3, 3.5, 5.0, and 8.8 psi. Twelve flat panes of plexiglas mounted on cubical wooden boxes wee exposed head-on to similar overpressures. Masses, velocities, and spatial densities of the fragments were detailed for the boxes and for the crew and cargo sections of the helicopters. Approximations to the mass-velocity distributions were derived using regression analyses.

K0121

AUTHOR

TITLE D.A.S.A. - A.E.C. Blast Tube Facility, Operated by Lovelace Foundation for Medical Education and Research for the Defense Atomic Support Agency, Albuquerque, NM

SOURCE Descriptive Brochure, Lovelace Foundation for Medical Education and Research, Albuquerque, NM, circa 1965-1970.

ABSTRACT

K0122

AUTHOR Richmond, D. R. and Fletcher, E. R.

TITLE Blast Criteria for Personnel in Relation to Quantity-Distance

SOURCE In Proceedings of the Thirteenth Annual Explosives Safety Seminar, September 14-16, 1971, San Diego, Calif, pp 401-419, Armed Services Explosives Safety Board, Washington, DC, 1971

ABSTRACT It is the objective of this paper to present some of the air blast criteria for personnel in a form considered pertinent to the interests of the Armed Forces Explosives Safety Board. This paper will give blast criteria for man standing in the open, primarily for the direct overpressure and displacement effects in terms of quantity-distance. In order to put these criteria in the proper perspective, some information on crater ejecta will be included. Blast effects for personnel inside structures will also be discussed.

K0123

AUTHOR Fletcher, E. R.

TITLE Translational Problems in Shelters

SOURCE Report, Minutes of Fifth Meeting, Panel N-1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, US Naval Radiological Defense Laboratory, San Francisco, CA and Lovelace Foundation, Albuquerque, NM, pp H-1 to H-21, May 10-14 1965

ABSTRACT The potential problems associated with the use of blast doors on group shelters were discussed briefly. An experiment was described in which the translational effects of air blast were investigated in an underground open-entryway shelter exposed on a full scale nuclear weapons test.
Computed peak dynamic pressure and the associated air temperature occurring in the open entryways of shelters were presented as functions of the magnitude and orientation of the incident shocked blast wave for two entryway configurations. Also, computed impact velocities were given for man in various positions as a function of his initial distance form the end of a long tubular shelter with open entryway exposed to long-duration blast waves of various magnitudes. The optimum location of an individual in such a shelter was discussed briefly with consideration also being given to the effects of overpressure per se (primary blast effects).
It was suggested that future investigations of the blast environment in open-entryway shelters could be accomplished by numerical methods with high-speed computers using modifications of computational techniques which have been developed for other purposes. The type and usefulness of the results that might be expected were discussed.

K0124

AUTHOR Bowen, I. G.

TITLE Underwater Blast Criteria

SOURCE Letter of transmittal w/enclosure, Lovelace Foundation for Medical Education and Research, submitte to U. S. Naval Ordnance Laboratory, MD., August 1968

ABSTRACT Addressing issues for future underwater blast studies at the Lovelace test facility.

K0125

AUTHOR Richmond, D. R. and Kilgore, D. E. Jr.

TITLE Blast Effects Inside Structures

SOURCE Report, Lovelace Foundation for Medical Education & Research, Proc. of the 2nd Conf. on Mil. Appli. of Blast Simulators, Nov 2-5, 1970, Naval Weapons Laboratory, Dahlgren, VA, pp 781-804, DNA-2775P, Defense Nuclear Agency, Wash., DC, May 19, 1972

ABSTRACT Introduction: Shock Tubes for Blast Biology Research. The first investigator to employ a shock tube for studying the physiological effects of blast as Cassen at UCLA in 1959. Five years later Celander et al in Sweden used a shock tube to study duration effects on mice by varying the length of the compression chamber. In 1958, Schardin and Wunsche at the French-German Research Institute, Saint-Louis, employed an air-driven shock tube to study the blast tolerance of rats mounted in a small depression in the floor of the tube at various distances from a reflecting plate. Anderson, in 1959, using the BRL Shock Tube, studied air blast displacement effects in goats and, in more limited studies, on the overpressure effects on mice in a side chamber.
This laboratory has used shock tubes for biomedical investigations of blast and shock since 1958. Much of the earlier efforts involved determining the tolerance of different animals to sharp-rising blast waves as a function of duration. These studies were aimed at estimating man's tolerance to air blast in the open. At the same time work was underway to determine the physiological alterations associated with air-blast injury in order to provide a basis for treatment. In this regard, the shock tube is a valuable tool. Physiological monitoring devices can be placed close to the animal adjacent to the shock tube in contrast to explosives in the open where long leads are necessary to connect the sensor with the recorders. In the last few years, our work was also aimed at determining the blast effects inside structures, portions of which will be the subject of this presentation.

K0126

AUTHOR Johnson, D. L. and Patterson, J. H.

TITLE Effectiveness of a Leaking Earmuff Versus a Leaking Earplug

SOURCE Technical Report, EG&G Special Projects and US Army Aeromedical Research Laboratory, Fort Rucker, AL., USAARL 97-23, July 1997

ABSTRACT The proper use of hearing protection in high noise level environments is a matter of concern. The attenuation achieved in real-world usage is seldom optimal. As study of the effects of high-intensity impulse noise (up to a 193 dB peak pressure level) on the hearing of humans wearing hearing protection included both an earplug and an earmuff. Both the plug and muff were degraded by holes that allowed a free pathway between the outside of the protector and the external ear canal. This simulated a poor fit of these protectors. The real ear attenuation was similar for both devices except at 500 Hz where the muff provided about 8 dB more attenuation than the plug. The Noise Reduction Rating (NRR) of both protectors was about the same (1 dB for the plug and 3 dB for the muff). The actual performance of the devices was vastly different. The muff provided protection at impulse noise levels at least 6-13 dB higher than the plug.

K0127

AUTHOR Richmond, D. R., Yelverton, J. T. , Fletcher, E. R., Phillips, Y. Y., Jaeger, J. J. and Young, A. J.

TITLE Damage-Risk Criteria for Personnel Exposed to Repeated Blasts

SOURCE Minutes of the Twentieth Explosives Safety Seminar, Norfolk, VA 24-26 Aug 1982, Vol. II, pp 1489-1512

ABSTRACT Damage-risk criteria for man subjected to one or twenty short-duration blast waves were presented in terms of peak overpressure, duration, overpressure impulse, range, and yield. Threshold and severe injuries to the lungs, gastrointestinal tract, and larynx were considered. Predictions of a 1-percent probability of mortality and selected injury levels were also given for repeated blasts of long duration. The results suggested that repeated blasts for subthreshold levels for a single exposure do not cause gross nonauditory injuries. For repeated blasts above threshold levels, the severity of blast injuries tended to increase with the number of blasts.

K0128

AUTHOR Richmond, D. R., Yelverton, J. T., Fletcher, E. R., and Phillips, Y. Y.

TITLE Biologic Response to Complex Blast Waves

SOURCE Technical Report, LA-UR, Los Alamos National Laboratory, in Proceedings Ninth International Symposium MABS 9, Oxford, England, September 23-27, 1985

ABSTRACT Small, bare charges were detonated inside an M59 armored personnel carrier (APC) in an attempt to simulate the complex blast waves generated by the jets from shaped-charge warheads penetrating into armored vehicles. Anesthetized sheep were placed inside the APC at 91- and 122-cm ranges from 57- or 113-g pentolite charges. Pressure-time was measured by pressure transducers either mounted on the animals or free standing at comparable ranges on the opposite side of the vehicle. In general, the waveforms were characterized by an initial shock wave of less than 1-msec duration followed by repeated reflections of decreasing magnitude. No deaths nor lung hemorrhages were observed, but all the animals sustained severe ear injury. Animals subjected to peak overpressures of 1.2 to 2.3 bar from the 113-g explosions also received slight nonauditory blast injuries to the upper respiratory and gastrointestinal tracts; those exposed to peak overpressures of just under 1 bar from the 57-g charges did not. The nonauditory blast injuries inside the APC were more severe than those sustained by sheep at comparable distances from 113-g charges in the open. The results suggested that the biological consequences of a complex wave of the type encountered in this study may be equated approximately to a Friedlander wave with a peak overpressure equal to that of the complex wave and with a total impulse equal to the impulse over the first 2 to 3 msec of the complex wave.

K0129

AUTHOR Richmond, D. R.

TITLE Double Peak Study

SOURCE Results Report, Lovelace Biomedical and Environmental Research Laboratory, prepared for Department of the Army, Walter Reed Army Institute of Research, Department of Clinical Physiology, Washington, DC, June 18, 1982

ABSTRACT Objective: Part I: The objective of Part I of this study was to demonstrate a blast resonance effect on lung injury in sheep by subjecting them to two blast waves delivered at 2-msec intervals from 0 to 14 msec. Part II: The object of this portion of the study was to obtain a high-level of lung injury in sheep given two blasts separated by 10 msec and then reduce the time between blasts to near 4 msec to see if the severity of the lung lesions would decrease.

K0130

AUTHOR Yelverton, J. T., Viney, J. F., Jojola, B. III, and Jones, R. K.

TITLE Exercise Tolerance of Rats Following Exposure to Gamma Radiation

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, 1971 (unpublished)

ABSTRACT A total of 512 female albino rats, Spraque-Dawley strain, were utilized for a series of exhaustive swim experiments conduct at water temperatures of 20 plus or minus 0.5 degrees C. The study was conducted in an effort to (1) determine the effect of LD50-30 day (894R) and LD50-5 day (956R) doses of Co60 gamma radiation on the ability to perform strenuous exercise at various times following exposure, (2) investigate the influence of exhaustive exercise on the lethality of irradiated rats and (3) determine a period of time when exercise capacity is restored to normal or near-normal levels.

Rats exposed to LD50-30 day radiation doses did not demonstrate a reduction in swim times when swam at 1 day after exposure, but those animals that were swam at 7, 14, or 30 days did. Animals exposed to LD50-5 day doses did not show any significant changes in exercise capacity at 2, 24, 48, or 96 hours post-exposure. It was found that exhaustive exercise occurring at various times after irradiation did not significantly influence mortality or survival times even at exposure doses that resulted in 97-percent lethality in 18 days. Survivors from the group that was swam at 14 days displayed a progressive recovery in swim performance which reached pre-exposure levels during the ninth week following irradiation.

K0131

AUTHOR White, C. S., Bowen, I. G., and Richmond, D. R.

TITLE The Environmental Medical Aspects of Nuclear Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, presented at the Twentieth Anniv. meeting and National Preparedness Symposium, sponsored by National Institute for Disaster Mobilization, Inc., Washington, DC, 1962

ABSTRACT The nature of certain critical lesions seen after exposure to air blast was described and the early lethality characterizing primary and tertiary blast damage was emphasized along with the seriousness of injuries caused by blast-energized debris. Tentative criteria were developed to the end that different levels of environmental variations caused by blast phenomena could be quantitatively related to various levels of biological response. Using the "free-field" scaling laws and a mathematical model whereby translational velocities could be computed for animate and inanimate objects, the criteria were applied to nuclear explosions ranging in yield from1 kt to 100 Mt. Thus, it was possible to specify, as a function of yield, the hazard range inside which various blast injuries might occur. At these ranges the associated levels of initial nuclear and thermal radiation were computed to allow at least some assessment of the relative importance of all the major hazards from nuclear detonations.

K0132

AUTHOR Johnson, D. R., Yelverton, J. T., Hicks, W. and Doyal, R.

TITLE Auditory and Nonauditory Damage-Risk Assessment for Simulated Weapons Fired from an Enclosure

SOURCE Presentation, EG&G MSI, in Proceedings, 14th International Symposium, Military Aspects of Blast and Shock (MABS), Las Cruces, NM 10-15 Sep 1995, Section 6- Biological Effects of Airblast

ABSTRACT A test apparatus was fabricated to simulate the blast environment to establish the damage risk from the reverberant wave produced from the firing of an antitank weapon from an enclosure. The simulation was accomplished by detonating C-4 explosive charges outside a 18.2 m3 all-steel chamber. The blast wave was introduced into the chamber through a 20-cm I.D. tube and was reflected off the back wall and subsequently throughout the chamber. The resulting waveform at the target locations closely approximately that generated by a Carl Gustav antitank weapon fired from a room of about the same volume. The nonauditory threshold was first estimated by exposing anesthetized sheep to various intensities of this reverberant wave environment. A series of 1-shot, 3-shot and 12-shot (2.5 minute intervals) exposures were done. The results indicated that multiple shots have a strong additive effect, decreasing the threshold levels. The threshold for a single exposure was estimated to be near a maximum peak pressure of 65 kPa and near a maximum peak of 46 kPa for three exposures. The threshold for 12 exposures was not found. Forty anesthetized sheep were used statistically to establish 48 kPa for one shot and 44 kPa for three shots as subthreshold levels in which no injury occurs. The auditory limit for the one- and three-shot exposures was then investigated. Using at least 60 human volunteers, a temporary change in hearing level was used as the primary measure of blast effect. Other parameters measured were performance assessment, stool guaiacs, tympanometry, physical well being, and otacoustic emissions. Each subject wore an RACAL muff, modified so it simulated leaks typical of a poorly fitted muff. The exposures were started at levels of approximately 1/64 of the energy of the final condition. The final conditions were set at the nonauditory threshold limits. Providing no effects occurred, the exposure energy was doubled for the next exposure, i.e., the second exposure was 1/32 of the energy of the final condition, until the nonauditory subthreshold level was reached. No auditory effects occurred. Thus, nonauditory considerations set the safe limit for firing a Carl Gustav-type weapon from an enclosed bunker.

K0133

AUTHOR Vassout, P., Dancer, A., Richmond, D., and Phillips, Y.

TITLE Biological Effects of Strong Shock Waves: Influence of the Pulse Duration in Repeated Exposures

SOURCE Institute Saint-Louis (ISL), Note S-N 911/84, Saint Louis, France, June 26, 1984

ABSTRACT Experiments carried out in the United States and at ISL enabled us to show clear intestinal lesions in pigs and sheep under the conditions of repeated (20) exposures to shock waves of 100 kPa of peak overpressure and of 4 ms duration of first positive phase. A duration of 2 ms does not produce very large lesions while a duration of 4 ms produces lesions in the larynx, the trachea and the intestine. The lungs are not affected by such shock waves.

K0134

AUTHOR Fletcher, E. R.

TITLE Probit Analysis Tables - Individual and Parallel

SOURCE Lovelace Foundation for Medical Education and Research, personal files, (no date)

ABSTRACT Individual and Parallel Probit Analysis (confidence levels)

K0135

AUTHOR Richmond, D. R.

TITLE Table, "Injury in Sheep in Relation to Peak Overpressure and Impulse, Twenty Blasts Each"

SOURCE Lovelace Biomedical and Environmental Research Institute, Albuquerque, NM, prepared for Walter Reed Army Institute of Research, Washington, DC, March 30, 1982

ABSTRACT Letter of transmittal with enclosure, Table "Injury in Sheep in Relation to Peak Overpressure and Impulse, Twenty Blasts Each"

K0136

AUTHOR Richmond, D. R.

TITLE A Safe Method for Safely Exposing Individuals at Distances of 0.5 to 2 M from the Source of an Explosion

SOURCE Draft Report, Los Alamos National Laboratory, Blast Overpressure Project, Albuquerque, NM to Walter Reed Army Institute of Research, Washington, DC, September 4, 1987

ABSTRACT Three methods to create blast conditions analogous to muzzle blasts from mortars with very short A-durations on the order of 1 msec or less are described.

K0137

AUTHOR Richmond, D.R.

TITLE The Response of Dummies Inside a C3 Tactical Shelter on a CVCV Truck Exposed to Blast and Thermal on Event Misty Picture - U.S. Army Natick, Experiment 1015

SOURCE Draft Report, Los Alamos National Laboratory, LS-1 KAFB Site, to American Development Corporation, North Charleston, SC, January 1988

ABSTRACT (need abstract or intro)

K0138

AUTHOR Richmond, D. and Josephson, L.

TITLE Blast Overpressure Report, Life Fire Test/Crew Casualty Assessment Workshop,

SOURCE Minutes Final copy, co-chairman's, Working Group IV, EG&G Mason Research Institute and Naval Weapons Center, China Lake, CA, submitted to The Analytical Sciences Corporation, Fort Walton Beach, FL, 1988

ABSTRACT Review of nature of blast injuries and existing blast overpressure casualty criteria; mathematical models; instrumentation; deficiencies of current criteria, etc.

K0139

AUTHOR Richmond, D. R.

TITLE Comments on Draft USANCA Nuclear Notes No. 9, Nuclear Weapons Effects Mitigation Techniques

SOURCE Draft comments, Lovelace Biomedical and Environmental Research Institute, to US Army Nuclear Chemical Agency, Springfield, VA

ABSTRACT Review of document by staff of Lovelace Biomedical and Environmental Research Institute.

K0140

AUTHOR Richmond, D. R.

TITLE Proposed Nuclear Effects Mitigation Techniques

SOURCE Draft report, w/ltr of transmittal, Lovelace Biomedical and Environmental Research Institute, to US Army Nuclear Chemical Agency, Springfield, VA, February 1981

ABSTRACT Scientific review of document by Lovelace Staff.

K0141

AUTHOR Richmond, D. R.

TITLE Tables: Blast Lesions in Animals, DRC Study

SOURCE Progress report data tables, Lovelace Biomedical and Environmental Research Insitute, to Walter Reed Army Institute

ABSTRACT [N/A]

K0142

AUTHOR Richmond, D. R.

TITLE Current Research and Development on the Bioeffects of Blast

SOURCE Lovelace Biomedical and Environmental Research Institute, Albuerque, NM. Presented at Joint UK/US Navy Workshops on R&D for Improved Combat Casualty Care, Institute of Naval Medicine, Alverstoke, Hampshire, England 27-31 July 1981

ABSTRACT Overview of current research and development on the bioeffects of blast.

K0143

AUTHOR Richmond, D. R.

TITLE Tables, WRAIR Pulmonary Vascular Permeability Study, Pressure Time Parameters

SOURCE Data Report, Lovelace Biomedical and Environmental Research Institute, to Walter Reed Army Institute of Research, Washington, DC, submitted May 21, 1983

ABSTRACT [n/a]

K0144

AUTHOR Richmond, D.R.

TITLE Current Status on Impulse Noise Induced Nonauditory Injury In Sheep

SOURCE Pathology Report, Lovelace Biomedical and Environmental Research Institute, to Walter Reed Army Institute of Research, Washington, DC, July 25, 1978

ABSTRACT [n/a]

K0145

AUTHOR Damon, E. G.

TITLE Reduction and Analysis of Range/Response Data

SOURCE Personal Correspondence, E.G. Damon to D. R. Richmond, LS-1 KAFB Site, Los Alamos National Laboratory, Albuquerque, NM, May 24, 1989

ABSTRACT [n/a]

K0146

AUTHOR Richmond, D. R.

TITLE Tables, Quick Look at the Incidence of Sinus Hemorrhages from Blast In Several Species

SOURCE Status Report, Lovelace Biomedical and Environmental Research Institute, to Walter Reed Army Institute of Research, June 23, 1978

ABSTRACT Tabulations of data from mortality studies to obtain LD50's and from studies to determine the pressures for threshold lung hemorrhages. The short-duration data are from H.E. blasts and the long-duration data.

K0147

AUTHOR Yelverton, J. T.

TITLE Tables, Lung Inflation Study

SOURCE Status Report, Lovelace Biomedical and Environmental Research Institute, to Walter Reed Army Institute of Research, Washington, D.C., October 1982.

ABSTRACT [n/a]

K0148

AUTHOR Fletcher, E. R.

TITLE Lung Model Program Computer Runs , Burroughs R-5500 Algol Compiler Level 12

SOURCE Personal Files, Lovelace Foundation for Medical Education and Research, Albuquerque, NM, November 23, 1970

ABSTRACT [n/a]

K0149

AUTHOR Yelverton, J. T.

TITLE Tables, Penetration of Glass Fragments Into Sheep Corneas

SOURCE Personal notes, Lovelace Biomedical and Environmental Research Institute, Albuquerque, NM, November 1975

ABSTRACT

K0150

AUTHOR Clifford, C. B.

TITLE Gross Scoring System of Lesions Produced by Blast Overpressure

SOURCE Notes of Meeting, Department of Comparative Pathology, Division of Pathology, Walter Reed Army Insitute of Research, Washington, DC, w/ltr of transmittal, 27 May 1982

ABSTRACT Preliminary version of Gross Scoring System developed by Walter Reed Army Insitute of Research and Lovelace Biomedical and Environmental Research Insitute.

K0151

AUTHOR Richmond, D. R.

TITLE Tables, Results of Experiments on Gastrointestinal Tract Injury

SOURCE Status Report, Lovelace Biomedical and Environmental Research Institute, to Walter Reed Army Institute of Research, Washington, DC, February 19, 1981

ABSTRACT Table 1 shows there were remnants of injury in the G.I. Tract, bodywall and larynx of sheep seven days after they received 50 blasts of 15 psi. Table 2 gives the control data. Table 3 gives the results from two sheep given 50 blasts of 75 psi for four consecutive days. Table 4 gives the results from two sheep that received 50 blasts of 7.5 psi one day only. Table 5 gives the negative findings in the blood-fed sheep.

K0152

AUTHOR Richmond, D. R.

TITLE Results Tables, Underwater Blast Internal Effects

SOURCE Progress Report, Lovelace Biomedical and Environmental Research Institute, to Explosives Technology, Fairfield, CA, 26 October 1976

ABSTRACT Results tables with letter of transmittal.

K0153

AUTHOR Fletcher, E. R.

TITLE Tables, To Be Included in the Effects of Nuclear Weapons Slide Rule

SOURCE Correpondence, Lovelace Foundation for Medical Education and Research, to Stanford Research Institute, Menlo Park, CA, October 25, 1974

ABSTRACT Six tables with letter of transmittal.

K0154

AUTHOR Richmond, D. R.

TITLE Nonauditory Biological Effects of Exposure to Repeated Blasts

SOURCE Foreign Travel Reports, NATO RSG6 , Notes, Lovelace Biomedical and Environmental Research Institute, to Department of Energy, Albuquerque, NM, with letter of transmittal, 21 Aug 1981

ABSTRACT Foreign travel trip reports discussing exchange of information re blast biology programs on nonauditory biological effects of exposure to repeated blasts and Swedish visiting scientist.

K0155

AUTHOR Richmond, D. R.

TITLE Tables, Hematocrit Values and Postmortem Findings, Blood Marker III Study

SOURCE Results Report, Lovelace Biomedical and Environmental Research Institute, to Walter Reed Army Institute of Research, Washington, DC, 10 November 1980

ABSTRACT Tables 1 and 2, with letter of transmittal.

K0156

AUTHOR Richmond, D. R.

TITLE Proposed Nuclear Effects Mitigation Techniques for Airblast Effects on Personnel

SOURCE Correspondence, Lovelace Biomedical and Environmental Research Institute, 1988

ABSTRACT [n/a]

K0157

AUTHOR Richmond, D. R.

TITLE Tests Run to Evaluate the Effects of Time Between Repeated Blasts

SOURCE Personal correspondence to D. L. Johnson, Blast Overpressure Project-Kirtland Air Force Base, EG&G MSI, Albuquerque, NM, January 1996

ABSTRACT [n/a]

K0158

AUTHOR Johnson, D. L.

TITLE M-17 and M-43 Chemical Defense Masks

SOURCE Photographs, Personal communication D. L. Johnson to J. Patterson.

ABSTRACT Photographs from M-17 tests and M-43 aviator mask done on 23 Jan 1991 and 20 Feb 1991, respectively.

K0159 DASA-1860

AUTHOR Richmond, D. R., Damon, E. G., Fletcher, E. R., Bowen, I. G. and White, C.S.

TITLE The Relationship Between Selected Blast Wave Parameters and the Response of Mammals Exposed to Air Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, Nov 1966

ABSTRACT Shock tube and high explosives were used to produce blast waves of various pressure-time patterns in order to study their biological effects. Data obtained form these experiments showed that, against a reflecting surface, the LD50 reflected pressure for any given species remained fairly constant at the "longer" durations and then rose sharply at the "shorter" times. For dogs and goats, "long" durations were beyond 20 msec and for mice, rats, guinea pigs, and rabbits, beyond 1 to 3 msec. At the "shorter" durations, response depended to a great extent on the impulse, and on peak pressure for the "longer" pulses. Higher reflected pressures can be withstood if animals are located beyond a certain distance from the reflecting surface where they receive the incident and reflected pressures in two steps separated by a given time-interval. In freestream exposures to air blast, orientation was significant. Animals suspended vertically or prone-side-on showed a lower tolerance to blast waves of a given intensity or at a given range than those end-on because the dynamic pressure appeared to add to their side-on pressure dose. Except for eardrum rupture and sinus hemorrhage, animals exhibited a remarkable tolerance to "slow"-rising blast pressures without the presence of shock fronts.

The lungs are considered the critical target organs in blast effects studies. The release of air bubbles from disrupted alveoli of the lungs into the vascular system probably accounted for the rapid deaths. The degree of lung hemorrhage was related to both the blast dose and the increase in lung weight over control values. For large animals, the threshold for petechial hemorrhage was near 10 to 15 psi at "long" durations and 30 to 35 psi for pulses of 5 msec. At LD50 values lung weights were two to four times normal.

Ear injury was not systematically studied; however, data gleaned from lethality and lung-injury experiments indicated that: eardrum response to blast pressures is subject to wide variation; a duration effect was observed in sheep, with 38-percent rupture recorded at 21.4 psi for durations near 100 msec versus no eardrum rupture at 32.4 psi when the durations were about 5 msec; and the severity of ear damage increased with the intensity of the blast.

From the presented data, tentative estimations of man's response to "fast" rising pressures of 3-msec duration were compiled. Pressures for threshold and severe lung-hemorrhage levels were 30 to 40 and above 80 psi, respectively. The threshold for lethality was 100 to 120 psi with an LD50 range of 130 to 180 psi. Time-honored estimates for human eardrum rupture values of 5 and 15 psi, respectively, for threshold and 50 per cent could not be revised at this time.

The estimates were given in terms of maximal effective pressures, which may be received from the incident, incident plus dynamic, or reflected pressure, dependent on orientation. For an individual against a reflecting surface that is normal to the incident shock, or prone with the charge detonated overhead, the maximal effective dose is the reflected pressure. If, however, the man is standing a few feet from this same reflecting surface or directly below the charge, he is subjected to pressures that rise in two steps; whereas, in the former situation, the maximal effective pressure would probably be the incident plus the dynamic pressures in the first step and, in the latter, only the side-on incident pressure in the initial step. The exact distance from a reflecting surface where the effective pressure changes form the reflected to incident, or incident plus dynamic, cannot be stated for man at this time. For personnel standing or prone-side-on to the charge when it is detonated at or near the surface, the side-on incident plus dynamic pressures become the effective pressure; however, with orientations end-on in this situation, only the side-on incident pressure appears to be the maximal effective pressure.

K0160

AUTHOR Richmond, D. R.

TITLE Tables, Series I: Incident Shock Pressures Measured Adjacent to the Foxhole Containing Rats (Foxholes)

SOURCE Personal Papers, Lovelace Foundation for Medical Education and Research, Albuquerque, NM (undated)

ABSTRACT [n/a]

K0161

AUTHOR Richmond, D. R. and Fletcher, E. R.

TITLE The Effects of Smooth-Rising Air Blasts on Animals

SOURCE Draft Technical Progress Report, Lovelace Foundation for Medical Education and Research, to Defense Atomic Support Agency, Washington, DC, 1970

ABSTRACT (need abstract - check if published)

K0162

AUTHOR Richmond, D. R. and Fletcher, E. R.

TITLE Comments on Blast Effects on Personnel.

SOURCE Draft Comments, 6 pp, Lovelace Foundation for Medical Education and Research, to Institute of Nuclear Studies, US Army Combat Development Command, Fort Bliss, TX, December 1, 1970

ABSTRACT [n/a]

K0163

AUTHOR Yelverton, J. T., Johnson, D. L. and Axelsson, H.

TITLE Review of Nonauditory Effects of Blast Overpressure

SOURCE Technical Report, EG&G Management Systems, Inc., to U.S. Army Medical Research and Materiel Command, Fort Detrick, MD (no date). Also, in Ototoxic Effects of Chemics, Chapter 36, pp 447-461, (no date)

ABSTRACT Introduction: A basic understanding of the mechanics of blast injury was developed during and just after World War II. Research since that time has further added to the understanding of the effects of classical or Friedlander blast waves. One clear finding is that the gas containing organs are more vulnerable to direct blast than are the solid organs. This has led to the development of damage-risk criteria for blast injury in man. These criteria assume the lungs to be the most vulnerable organ in terms of immediate pathophysiological effects. Disruption of the lungs by a blast wave can lead to upper airway obstruction from hemorrhage, deleterious changes in blood-gas parameters from increased venous/arterial shunting, and congestive heart failure from increased pulmonary hypertension. At higher overpressure levels, the formation of alveolar-venous fistulae in the lung parenchyma permits air to enter the circulation. This can lead to early death from coronary and cerebral air embolism. Contusions and/or ruptures of the lining of the gastroenteric tract are also important. In addition, the onset of the effect of these lesions become more important with time. Criteria have also been established relating the severity of eardrum rupture to blast overpressure and duration.
Recent studies have shown that the upper respiratory tract can be important as an indicator of the possible presence of other nonauditory blast injuries during the initial medical assessment. It was observed that demonstrable hemorrhage changes tend to occur in the upper respiratory tract either before or concurrently with injuries to the gastroenteric tract and/or lungs,.
Data from the effects of complex wave experiments have shown that much of the results from freefield waves maybe applied to complex waves. However, complex waves may take on many forms, not all of which data are available to properly assess the risk. But for the specific case in which firing a rocket launcher from an enclosure is simulated, work has just been completed that establishes some noninjury thresholds.

K0164

AUTHOR Richmond, D. R. and Fletcher, E. R.

TITLE Comments on the Report Entitled "Preliminary Civilian Casualty Criteria for Low-Yield Nuclear Weapons (U)" DNA-3547T

SOURCE Comments by Lovelace Foundation for Medical Education and Research for Director, Defense Nuclear Agency, Washington, DC (formerly Confidential, downgraded 31 Dec 81)

ABSTRACT Review of DNA Report3547T "Preliminary Casualty Criteria for Low-Yield Nuclear Weaposn (U)." with letter of transmittal dtd September 8, 1975

K0165

AUTHOR Richmond, D. R.

TITLE Underwater Shock Facility and Explosion Levels Evaluated by a Swimmer

SOURCE Technical Paper, Contibution 4:2, pp 4:2:1-4:2:20, Lovelace Biomedical and Environmental Research Institute, presented at the 5th International Symposium on Military Application of Blast Simulation, Stockholm, Sweden, 23-26 May 1977

ABSTRACT An underwater shock facility was described and the results of tests conducted to determine the underwater-blast levels that would be comfortable to an unprotected swimmer were presented. Twenty-two tests were carried out in a 220- by 150-ft underwater facility (30 ft deep) with explosive charges up to 2.6 lb. Six tests were run in open water (25 and 150 ft deep) with charges up to 190 lb. On most of the tests the underwater-blast waveforms were measured by gauges located at 1-ft depths adjacent to the swimmer. The peak pressures, impulses (time-integral or pressure), and cut-off times were calculated from the gauge records and presented along with the sensations described by the swimmer. Impulses of 1.0 psi.msec or more were evaluated by the swimmer with his head above the surface for (a) peak pressures of 50 to 118 psi from charges fired at or deeper than a 10-ft depth of burst (DOB), (b) peak pressures of 139-216 psi from charges fired at a 1-ft DOB, (c) swimmer near a reflecting surface, and (d) swimmer in a wet suite. The noise from underwater explosions was also assessed while the subject's ears were at 1-ft depths, head facing the charges. The sounds from the following underwater blasts were tolerable and did not produce tinnitus: impulses of 0.25 psi.msec to 1.31 psi.msec with respective peak pressure of 12 psi to 52 psi (blasting caps, 10-ft DOB); and impulses of 1.0 to 2.0 psi.msec with peak pressures of from 48 psi to 71 psi (0.5-lb charges, 10-ft DOB). Some information on the bottom reflected waves, having atypical waveform, encountered was included. A 1-psi.msec criterion as an acceptable underwater-blast level for swimmers was discussed.

K0166

AUTHOR Richmond, D. R.

TITLE Tables and Pressure-Time Records, Blast Parameters and Parameters for Peak Overpressure Effects, and Gross Pathology - Isopressure-Isoimpulse Study

SOURCE Results Tables, Lovelace Biomedical and Environmental Research, to Walter Reed Army Insitute of Reserch, Washington, DC, 1981

ABSTRACT [n/a]

K0167

AUTHOR Richmond, D. R.

TITLE Results Table, Group V, 2.5 psi Administered 50 Times, Laryngeal Lesions Study

SOURCE Results Report, Lovelace Biomedical and Environmental Research Institute, to Walter Reed Army Institute of Research, Washington, DC, May 1980

ABSTRACT Gross pathology tabulations of blast injury to lungs, larynx-pharynx, and trachea for sheep exposed to blast ovepressure.

K0168

AUTHOR Fletcher, E. R.

TITLE Evaluation of Jeep and Anthropomorphic Dummy Displacements in the French Large Blast Simulator

SOURCE Final Technical Report, Lovelace Biomedical and Environmental Research Institute, prepared for Defense Nuclear Agency, Washington, D.C., January 1985

ABSTRACT Motion-picture records were analyze to obtain the time-displacement histories of anthropomorphic dummies in full-scale jeeps exposed to shockwaves in the Large Blast Simulator at Gramat, France. The shock overpressures ranged from 0.22 to 086 bar, and the positive overpressure durations were on the order of 1.10 to 1.35 sec.

K0169

AUTHOR Richmond, D. R. and Yelverton, J. T.

TITLE Forward Look - Effects from Tests Conducted May 25, 1978

SOURCE Final Report, Lovelace Biomedical and Environmental Research Institute, to Sandia Corporation, Albuquerque, NM, June 1978, w/letter of transmittal

ABSTRACT Introduction: At the request of Sandia Corporation, Lovelace Biomedical and Environmental Research Institute undertook the task of evaluating the blast environment behind a concrete wall subjected to shaped-charge warheads. Specifically, sheep were mounted at 3, 6, and 9 ft behind an 8-inch-thick reinforced-concrete wall subjected to the warheads from a 105-mm recoilless rifle, a TOW rocket, and a DRAGON rocket.
On May 25, 1978, four tests were run with animals and were designated Shot 1, 015 mm; Shot 2, TOW; and Shots 3 and 4, DRAGON.
It was planned to place animals outside of the anticipated path of the jet emanating from the shaped charge. However, due to the slight errors in hitting the aim point, three of the animals were in the jet.
The effects to be evaluated were those from fragments, direct blast (overpressure), blast displacement, and thermal.

K0170

AUTHOR Richmond, D. R.

TITLE Whole-Body Impact Studies With Sheep

SOURCE Presentation, Lovelace Biomedical and Environmental Research, DCPA Meeting, Asilomar, CA, April 21-25, 1974

ABSTRACT Introduction: The purpose of this paper is to present the results of experiments run to determine the response of sheep to whole-body impact against a nonyielding surface. The tests were run on behalf of the Defense Nuclear Agency in order to provide input data for developing air-blast displacement criteria for troops inside field fortifications. Information of this nature is of direct interest to civil defense in connection with estimating the hazards from air-blast displacements of people inside basement shelters.

K0171

AUTHOR Richmond, D. R. and Fletcher, E. R.

TITLE Proposed Revision of NFPA Standard No. 45

SOURCE Correspondence, Lovelace Biomedical and Environmental Research Insitute, to Sandia National Laboratories, Albuquerque, NM, 29 Sep 78

ABSTRACT Proposed revision to preliminary proposal to be submitted to the NFPA 45 Committee for their consideration and possible introduction into the standard revision process.

K0172

AUTHOR Fletcher, E. R., Richmond, D. R. and Hicks, W.

TITLE The Displacement of Anthropomorphic Dummies Inside an AMF-80 Shelter Subjected to H.E. Bombs

SOURCE Technical Report, Lovelace Biomedical and Environmental Research Institute, for Aeronautical Systems Division/AESD, Wright Patterson Air Force Base, OH, November 1983

ABSTRACT Objective: To estimate the personnel risk from blast displacement inside an AMF-80 shelter exposed to the detonation of H.E. bombs.
Background: Between 17 June and 5 August 1983, the U.S. Air Force conducted six tests to determine the response of an AMF-80 personnel shelter to 1000-lb and 500-lb bombs. This test series was held on Kirtland Air Force Base, NM. At the request of the USAF, the Lovelace Inhalation Toxicology Research Institute provided an installed six anthropomorphic test dummies to simulate crew personnel in the shelter. Motion-picture records, accelerometers, and the postshot position and condition of each dummy were used to assess the potential risk to human occupants.

K0173

AUTHOR Bruner, A.

TITLE Immediate Changes in Estimated Cardiac Output and Vascular Resistance after 60Co Exposure in Monkeys: Implications for Performance Decrement

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Radiat. Res. 70: 391-405, 1977.

ABSTRACT Aortic blood flow velocity, blood pressure, and heart rate were recorded in 12 unanesthetized, nonperforming monkeys during exposure to 1000 rad 60Co at 129-164 rad/min. The first postradiation changes were seen within 3-4 min of the exposure's start and included tachycardia, transient hypotension secondary to a loss in peripheral resistance, and a brief increase followed by a decrease to subnormal levels in cardiac output. The lowest cardiac output occurred between 10 and 20 min postexposure while blood pressure and peripheral resistance were recovering. It was proposed that the concurrent combination of low cardiac output, low blood pressure, and supranormal peripheral resistance might sufficiently attenuate cerebral perfusion temporarily to account for the transient behavioral decrements often seen during this time. Histamine release was postulated as responsible for this vascular shock syndrome.

K0174

AUTHOR Richmond, D. R.

TITLE Proposed Revision to Draft on Standard for Single Point Explosives in Air

SOURCE Correspondence, Lovelace Foundation for Medical Education and Research, Alb., NM, to Sandia Laboratories, Jack Reed, Chairman, ANSI (material prepared for DOD Explosive Safety Board in 1971), January 5, 1973

ABSTRACT [n/a]

K0175

AUTHOR Richmond, D. R.

TITLE Trip Report on Fifth International Symposium on Military Applications of Blast Simulation and visit to Swedish Defense Institute

SOURCE Trip Report on Fifth International Symposium on Military Applications of Blast Simulation, Stockholm, Sweden, May 23-26, 1977 Lovelace Foundation for Medical Education and Research, Director, AFRRI, Bethesda, MD, 26 July 1977

ABSTRACT Comments of participant who presented important information on swimmer response to underwater blast and visit with Carl-Johan Clemedson, Surgeon General Retired, consultant to the Swedish Defense Institute, Tumba, Sweden.

K0176

AUTHOR Richmond, D. R.

TITLE Method Used Developing Direct-Blast Criteria for 50-Percent Combat Ineffectiveness of Troops in Foxholes, Sections I and II. Incident Shock Parallel and Perpendicular to Ground Surface

SOURCE Correspondence, Lovelace Foundation for Medical Education and Research, to USA Nuclear Agency/WED, Fort Bliss, TX, January 6, 1975

ABSTRACT Estimates are provided of blast levels necessary to produce 50% combat ineffectiveness of personnel inside foxholes from direct overpressure effects and from translational impact.

K0177

AUTHOR Young, A. J., Jaeger, J. J., Phillips, Y. Y., Fletcher, E. R.., and Richmond, D. R.

TITLE Intrathoracic Pressure in Humans Exposed to Short Duration Airblast

SOURCE Reprint, Walter Reed Army Institute of Research, Washington, D.C., Military Medicine, 150(9): 483, September 1985

ABSTRACT The purpose of this study was to determine the effects of airblast intensity, body orientation and arm position on human intrathoracic pressure responses to blast overpressure. Nine volunteers were exposed to low-level, short-duration air blast similar to artillery muzzle blast. At three levels of overpressure, the subject was exposed while standing face-on, side-on and back-on to the oncoming blast wave. Each combination of intensity and orientation was repeated once with the arms above the head, and once with arms down at the side. Results indicate that orientation of the body to the blast wave and position of the arms had no effect on the intrathoracic pressure responses exposure. Larger maximum intrathoracic pressures and rates of intrathoracic pressure change resulted from exposure to 18.3 kPa blast overpressure than 95. kPa. The observations suggest that, for low-level short-duration shock waves similar to artillery muzzle blast, the effects of the dynamic component of total overpressure and subject orientation and geometry on intrathoracic pressure responses during airblasts are small.

K0178 ITR-1447

AUTHOR White, C. S., Wetherbe, M. B., and Goldizen, V. C.

TITLE The Internal Environment of Underground Structures Subjected to Nuclear Blast. I. The Occurrence of Dust

SOURCE Preliminary Report, Lovelace Foundation for Medical Education and Research, Operation Plumbob, Project 33.5, Atomic Energy Commission, Civil Effects Test Group, Technical Services, Department of Commerce, Washington, DC, September 1957

ABSTRACT The possible occurrence of dust inside protective shelters as a consequence of nuclear explosions was studied using 18 underground structures subjected to atomic detonations during Operation Plumbbob at distances ranging from 4320 to840 ft from Ground Zero. The existence of considerable dust was established using sticky-tray fallout collectors. Particulates captured arose from dust on the floor existing preshot, from "dust leaks" in some shelters, and from the internal surfaces of the structures. The latter was established by treating the walls and ceilings of selected shelters with a fluorescent dye solution and subsequently demonstrated fluorescence of captured particles. Data available indicate that the dust collector technique will be useful in evaluating the environmental aspects of shelters tested in the future and that procedures showing fine spalling may be more sensitive indicators of structural response to dynamic loading than gross spalling. Should this indeed be established, the fluorescent method employed, or an equivalent, will become another simple routine test available to indicate structural response at greater ranges than is now possible without using complicated instrumentation.

K0179

AUTHOR Damon. E. G., Costello, M. L., Sedgwick, R. T., Phillips, T. T., and Richmond, D. R.

TITLE Biological Response of Sheep Exposed in an Armored Fighting Vehicle to Overpressures Generated from High Explosives or Shaped-Charge Warheads

SOURCE Technical Report, Los Alamos National Laboratory, prepared for S-Cubed, San Diego, CA, March 1990

ABSTRACT To assess the anti-personnel effects of shaped charge warheads (SC) and the protective effects of different types of armor, a total of 95 young adult ewes (including controls) were anesthetized and exposed to overpressures generated from different types of SC penetrating different types of armor or high explosives (HE) detonated within an armored fighting vehicle (AFV).

Sheep were necropsied after exposure and the immediate primary blast effects were assessed. Fatalities were necropsied immediately after death or within 1.5 hours after death. Survivors were sacrificed and necropsied within 3.5 hours after exposure.

Sheep exposed in the shaped charge tests exhibited injuries from penetrating missiles or fragments but primary blast injuries were limited to rupture of eardrums and fractures of the ossicles of the middle ear.

Primary blast injuries in sheep exposed to HE charge weights of 0.5, 0.75, 1.0, 1.25, or 1.5 lb ranged from ear injuries only, for those exposed to 0.5 lb charges at a range of approximately 3 ft, to massive pulmonary hemorrhage, coronary and/or cerebral air embolisms and fatalities in sheep exposed to 1.5 lb charges at the same range. Severe abdominal injuries including hemoperitoneum from rupture of solid organs (liver and/or spleen), submucosal and subserosal hemorrhages in the walls of gastrointestinal (GI) tract were also observed among those exposed to charge weights of 1.25 to 1.5 lb. Five sheep were fatally injured and died within 5 to 8 minutes after exposure. All of these sheep exhibited arterial air embolisms in the coronaries and/or the cerebral vessels. Surviving sheep exposed to 1.25 or 1.5 lb charges exhibited pulmonary hemorrhage ranging in severity from moderate to extensive and abdominal injuries ranging from slight to extensive.

Pressure-time measurements were made with piezoelectric pressure transducers. Transducers were mounted side-on and face-on to the shock wave on both sides of each sheep. The severity of primary blast injuries exhibited by the sheep correlated but poorly with the mean of the peak overpressures and the mean of the impulses in increments of 0.5 ms from 0 to 10 ms.

K0180

AUTHOR Clemedson, C-J. (Contributor)

TITLE Table 4. Effects of Underwater Blast: Man and Other Animals

SOURCE In: Altman, P. L. and Dittmer, D. S., Environmental Biology (photocopy, 3 pp)

ABSTRACT Contribution data are based on experiments with shock waves having an almost instantaneous rise of shock front pressure.

K0181

AUTHOR Richmond, D. R.

TITLE Personnel Casualties, Chapter 10, Section 1, Airblast, Revised Edition of DNA EM-1

SOURCE Draft, Lovelace Biomedical and Enrironmental Research Insitute, to Defense Nuclear Agency, Washington, DC, October 1981

ABSTRACT Draft includes section on Mechanism and Nature of Injuries and Casualty Predictions.

K0182

AUTHOR Fletcher, E. R.

TITLE Flying Glass Hazard from Windows Broken by Airblast

SOURCE Draft, Topical Report, Lovelace Foundation for Medical Education and Research, prepared for Director, Defense Nuclear Agency, Washington, DC, 1978

ABSTRACT The purpose of this study was to predict the flying-glass hazard to occupants of windowed structures exposed to various levels of airblast. A review of the literature indicated that additional experimental data would be required in order to make such predictions with confidence.
Experiments were conducted in which individual standardized glass fragments of several shapes and masses were impacted against bare or clothed subjects. The biological endpoint were (1) skin or body-all penetration for impacts on the thorax or abdomen and (2) skin penetration or skull fracture for impacts on the head. The data were analyzed and compared with results previously reported for either irregular glass fragments impacted in a random orientation or irregular acrylic fragments impacted point on.
In other experiments, 3x3-ft double-strength and 4.5x6-ft 1/4-inch-plate windows complying with the usual building codes were mounted in commercial aluminum frames on the end-plate using a 10-ft diameter shock tube. The windows were broken by blast waves with peak reflected (against the end plate) overpressures ranging from 0.55 to 10.1 psi. The number of incised wounds, skin penetrations, and body wall penetrations were recorded for bare and clothed subjects located 7 or 14 ft behind the windows. Figures were derived showing the average number of the various types of wounds per subject as a function of either the mean fragment impact velocity or the effective peak overpressure on the window. These figures can be used to predict the flying-glass injuries to subjects in a side-on orientation 7 ft from windows in relatively small enclosed structures (e.g., 1-or-2 story houses) exposed to long-duration blast waves.

K0183

AUTHOR Clark, R. O.

TITLE A Study of Shock-Driven Jets

SOURCE Draft Report, Lovelace Biomedical and Environmental Research Institute, Albuquerque, NM, (undated, unpublished)

ABSTRACT Pitot pressures and static pressures were measured throughout jets that were driven by incident and reflected pressures of shock waves in order to determine the range and attenuation of these jets as a function of the driver pressure and the shape and size of the orifice. The measurements showed the indicated dynamic pressure at the base of the jet to be related to the driver pressure according to the theory of a reversible process assumed for steady jets. The measurements also showed several oscillations of the jet boundary immediately behind the orifice when the jet exit flow was strongly supersonic. When these oscillations were averaged, the resulting attenuation of the indicated dynamic pressure was approximately linear and could be described by the same family of straight lines as the subsonic jets. The effect on the jet of the pressure surrounding the jet changing was taken into account, because this is bound to occur for jets driven into structures by shock waves. Thus, this study resulted in the development of a method for finding the indicated dynamic pressure anywhere in the jet for variables of static driver pressure and sizes and shapes of orifices. However, the studies were incomplete for jets driven by the side-on application of shock pressure and for the effects of varying the orifice depth. Some experiments showed that more work would be required to complete investigation in these areas since they introduced additional variables.

K0184 NWC TP 5771

AUTHOR Fletcher, E. R., Richmond, D. R., and Richmond, D. W.

TITLE Airblast Effects on Windows in Buildings and Automobiles on the Eskimo III Event

SOURCE Project Report, Lovelace Foundation for Medical Education and Research, Eskimo III Magazine Separation Test, Test and Evaluation Department, Naval Weapons Center, China Lake, CA, February 1976

ABSTRACT Objectives: The objectives of this project were: (1) to determine the velocities, masses, and spatial densities of the fragments from three types of standard plate-glass windows mounted in closed, cubical structures at three ranges from ground zero; (2) to determine the same quantities for window fragments inside three automobiles, one oriented side-on and two oriented head-on to ground zero; (3) to document the window damage in ten automobiles located at three ground ranges; (4) to study the response of a clothed anthropomorphic dummy (a) standing behind one of the plate-glass windows and (b) sitting in an automobile; and (5) to estimate the hazards to occupants of buildings and automobiles exposed to similar levels of airblast.

K0185

AUTHOR Fletcher, E. R.

TITLE Airblast Effects on Windows in Buildings and Automobiles - Eskimo II Test

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, presented at the 15th Armed Services Explosives Safety Board Meeting, San Francisco, CA, September 1973

ABSTRACT Twenty-six plate and double-strength glass windows were mounted in cubical structures at three pressure levels between 0.2 to 1.1 psi. Styrofoam witness plates were positioned behind six of the windows to determine the mass, velocity, and spatial distributions of the glass fragments. In addition, window breakup was evaluated in ten automobiles. An anthropomorphic dummy in one of the cubicles and in one of the automobiles was viewed with high-speed motion picture cameras. The results from Eskimo II were compared with data from earlier experiments, and the biological hazards of the glass fragments were estimated.

K0186

AUTHOR Fletcher, E. R. and White, C. S.

TITLE Biological Hazards from Blast-Induced Flying Glass

SOURCE Preliminary Report, Lovelace Foundation for Medical Education and Research and Oklahoma Medical Research Foundation, Trident Missiles Flight Test Program, Sandia Laboratories, Albuquerque, NM, October 1976

ABSTRACT Abstract not available.

K0187

AUTHOR Fletcher, E.R.

TITLE Analysis of the Motion-Picture Record of the Dummy in the Goodyear C3 Shelter

SOURCE Project Report, Los Alamos National Laboratory, Los Alamos, NM, to Goodyear Aerospace Corporation, Litchfield Park, AZ

ABSTRACT The dummy was seated in the Goodyear C3 shelter with its back against the chair and was secured with a lap belt and shoulder harness. Analysis of the dummy's displacement using the motion picture record was presented.

K0188

AUTHOR Yelverton, J. T., Richmond, D. R., Phillips, Y. Y., and Dodds, K.

TITLE The Influence of Kevlar Vests on Airblast Induced Lung Injuries

SOURCE Abstract, Los Alamos National Laboratory, Los Alamos, NM, of paper presented at the MABS 10 Symposium, submitted to Harry Diamond Laboratories, Adelphi, MD, September 11, 1986

ABSTRACT Anesthetized sheep wearing the standard U.S. Army Body Armor Fragment Protective Vest (Kevlar Vest) were exposed to a variety of airblast regimes. Subjects with and without Kevlar vests were given short-duration airblasts in the open from high-explosive charges; intermediate duration (15 msec) blasts in an explosive-driven shocktube; and complex blast waves generated by detonations of small charges within enclosures. The results showed a decreased tolerance to airblast in animals wearing Kevlar vests for all the pressure-time patterns studied. The bulk of the data was obtained with the 15-msec duration blasts. The LD50 (overpressure required for 50% mortality) was reduced from 4.8 bar for those without Kevlar vests to 3.5 bar for those wearing the vests. Overpressures to produce threshold lung injury levels were also lowered. Higher intrathoracic pressures were measured in both animals and volunteer personnel exposed to blasts when wearing Kevlar vests. Possible mechanisms that could explain the augmentation of blast effects by Kevlar vests and other soft materials were discussed.

K0189

AUTHOR Yelverton, J. T. and Johnson, D. L.

TITLE Large Animal Response to Complex Waves Generated in the EG&G Variable Volume Test Enclosure

SOURCE Presentation, EG&G Special Projects, Albuquerque, NM, at the RSG-6 Meeting, NATO Defense Applications of Biomedical Sciences Research Study Group 6, Panel 8, Effects of Impulse Noise, Albuquerque, NM, October 1991

ABSTRACT Objectives of Study: (1) To determine injury level as a function of range and charge weight in sheep exposed to single, bare H.E. charge detonations in various enclosure volumes; (2) to correlate the results from the above objective with those from other studies to establish the relationship of blast injury level to charge weight and enclosure size; and (3) to compare the results of these studies to the various injury prediction models that are being proposed for complex wave environments.

K0190

AUTHOR Richmond, D. R.

TITLE Biological Effects of Exposure to Multiple Blasts

SOURCE Draft Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC., 1971

ABSTRACT This report presents the results of studies conducted to investigate the biological effects of exposure to multiple blast overpressures. Although the data are limited to rats and sheep, they should be useful in predicting combat effectiveness and thus could be used in determining safety and casualty criteria for military personnel subjected to repeated blasts. It would also be useful as an aid in evaluating blast effects inside structures with small volume-to-area ratios where the blast wave is usually characterized by multiple shock fronts associated with reflections of the incident shock wave off the inner surfaces of the structure.

K0191

AUTHOR Richmond, D. R., Fletcher, E. R., Martinez, B. S., and Yelverton, J. T.

TITLE Blast Biophysics: Past, Present, and Future

SOURCE .

ABSTRACT Review of blast overpressure effects research through 1979.

K0192

AUTHOR

TITLE DASA-AEC-Lovelace Foundation Blast Simulation Facilities

SOURCE DASA Data Center Special Report 27, Blast and Shock Simulation Facilities in the UK, Canada, and the US, DASA-1627, Defense Atomic Support Agency, Washington, DC, April 1965

ABSTRACT Introduction: The primary purpose of the blast simulation facility is to generate air blasts for biomedical investigation of the effects of blast and shock. In order to generate a wide variety of pressure-time patterns essential to biological studies, nearly a hundred different shock-tube configurations have been utilized, and over half of them were tested with biological specimens. Shock tubes have a particular advantage in biomedical studies in that instruments that record physiological processes can be located close to an animal just outside the shock tube.
This facility consists of four highly versatile shock tubes and a concrete pad high-explosive test site.

K0193

AUTHOR Richmond, D. R. and Jones, R. K.

TITLE Safe Distances from Underwater Explosions for Mammals and Birds

SOURCE Technical Paper, Lovelace Biomedical and Environmental Research Institute, in Proceedings of the 1st Conf. On the Environ. Effects of Explosive and Explosions, May 1973, NOLTR 73-223, pp 113-118, Naval Ord Lab, Silver Spring, MD, 12 Feb 74

ABSTRACT Introduction: This report presents the results of tests run to determine the effects of underwater explosions on birds and mammals. The information should be of interest to government agencies and private industry groups required to prepare Environmental Impact Statements in connection with detonating high explosives in a water environment.

K0194

AUTHOR Richmond, D. R.

TITLE Safe Distances from Underwater Explosions

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Minutes of the Fifteenth Explosives Safety Seminary, San Francisco, CA, 18-20 Sep 73, vol II, pp 1450-1475, Dept of Def Exp Safety Board, Washington, DC

ABSTRACT Introduction: The purposes of this paper are (1) to summarize the results of tests run to determine how the biological effects of underwater blast fall off with range in the far field from small charges and (2) to present a tentative underwater-blast safety criterion for unprotected swimmers based on the results of the animal experiments and information gained from volunteer swimmers.

K0195

AUTHOR Fletcher, E. R., Richmond, D. R., and Richmond, D. W.

TITLE Airblast Effects on Windows in Buildings and Automobiles on the Eskimo III Event

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Minutes of the Sixteenth Explosives Safety Seminar, Volume I/II, pp 185-213, Department of Defense Exp Safety Board, Washington, DC, September 1974

ABSTRACT Objectives: (1) to determine the velocities, masses, and spatial densities of the fragments from three types of standard plate-glass windows mounted in closed cubical structures at three ranges from ground zero; (2) to determine the same quantities for window fragments inside three automobiles, one oriented side-on and two oriented head-on to ground zero; (3) to document the window damage in ten automobiles located at three ground ranges; (4) to study the response of a clothed anthropomorphic dummy (a) standing behind one of the plate-glass windows and (b) sitting in an automobile; and (5) to estimate the hazards to occupants of buildings and automobiles exposed to similar levels of airblast.

K0196

AUTHOR Richmond, D. R., Yelverton, J. T., and Fletcher, E. R.

TITLE Blast Injuries Produced by the Detonation of Small Charges Within an Enclosure

SOURCE Draft Report, Lovelace Biomedical and Environmental Research Institute, prepared for Division of Medicine, Walter Reed Army Institute of Research, Washington, DC (undated]

ABSTRACT This report gives the results of exploratory experiments dealing with the effects of complex blast waves. Sheep were exposed to complex blast waves while inside an M59 armored personnel carrier (APC) in which 57- or 113-g pentolite charges were detonated. Pressure time was measured by pressure transducers located on the animals and at comparable ranges. In general, the waveforms consisted of a high initial shock front of short duration (less than 1 msec) followed by repeated reflected shocks of decreasing magnitudes. There were no lung hemorrhages observed. Most of the animals sustained severe ear injury. Those inside the APC, subjected to the 113-g explosions, also received slight nonauditory blast injuries in the upper respiratory tract and gastro-intestinal tract; those exposed to the blast from the 57-g charges did not. The nonauditory blast injuries inside the APC were more severe than were those sustained by sheep at comparable distances from 113-g charges in the open. The initial peak pressure and impulse over the first 2-3 msec of the wave was suggested as the effective airblast dose for complex blast waves of the form encountered in this study. The significance of ear injury on the performance of crew personnel was discussed.

K0197

AUTHOR Richmond, D. R.

TITLE Direct Airblast Effects in the Open Including Multiple Blasts

SOURCE Personal Papers, unpublished (undated)

ABSTRACT (Abstract not available)

K0198 WT-798

AUTHOR Richmond, D. R.

TITLE Effects of Overpressures in Group Shelters on Animals and Dummies, Project 23.15, Operation Upshot-Knothole

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, Civil Effects Test Group, Nevada Proving Grounds, Atomic Energy Commission, Washington, DC, March-June 1953

ABSTRACT Relative biological hazards of blast were studied in two types of communal air-raid shelters during Shots 1 and 8 (Nevada Proving Grounds, 1953). Dogs, restrained within the shelters during detonation, were studied pathologically and clinically for blast injuries. Two anthropometric dummies were test objects for displacement studies utilizing high-speed photography. Physical data included pressure vs time and air-drag determinations.
During Shot 1 animals sustained marked blast damages (hemorrhages in lungs and abdominal organs), three dogs were ataxic and the dummies were rather violently displaced. In Shot 8, however, no significant injuries were found in the animals, and the dummies were minimally displaced.
Analysis of the physical data indicated that blast injuries and violent displacements may occur ar much lower static overpressures than previously assumed from conventional explosion data. Furthermore, biological damage appeared to e related to the rate of rise of the overpressure and air drag, as well as the maximum overpressure values. These phases of the problem should be defined by further investigation.

K0199

AUTHOR Richmond, D. R. and Damon, E. G.

TITLE Biomedical Effects of Impulse Noise

SOURCE Technical Report, Fortifikatorisk Notat Nr 209/93, support provided by Office of Test Development, Norwegian Defense Construction Service, Oslo, Norway, September 1993

ABSTRACT This review paper deals with the biomedical effects of intense impulse noise on the auditory and nonauditory systems of the body. Injury parameters of the impulse noise wave, damage risk criteria (DRC) and protective measures are included.
Impulse noise effects on the middle ear consist of ear drum rupture and/or conductive hearing loss. Within the cochlea of the inner ear there is damage to the hair cells (that convert sound vibrations into nervous signals), and associated tissues resulting in a sensorineural hearing loss. The latter is more common because it occurs at lower pressures than conductive loss. Ear protectors, ear muffs, ear plugs and helmets, can reduce sound pressure levels on the average of 25 dB. However,, this is not realized in practice unless there is proper supervision in their fitting. Ear protection is required for impulse noise exposures above 140 dB in the USA army standard. There are upper allowable limits in the various auditory DRC that should not be exceeded because of the possibility of nonauditory injury.
Pathology to the nonauditory systems is confined mainly to the lung, upper respiratory and gastrointestinal tracts. Lung hemorrhage results in respiratory distress and when severe, death from entrance of air bubbles (air emboli) into the circulation. Bleeding or perforation of the gastrointestinal tract occurs at those sections containing gas -- stomach, large intestine and rectum. Pressure levels required for nonauditory injury depends on the duration of the pressure, the number and time distribution of exposures and whether or not the wave has a complex form.
During field studies involving weapon firings and simulated weapon noise, soldiers wearing ear protectors have experienced impulse noise levels well above the allowable limits in the auditory DRC's. There was a low incidence of temporary threshold shifts that recovered with no detectable nonauditory effects. There were, however, complaints of pains in the chest, headache, sleeplessness, general discomfort, etc. The need for the development of a garment to protect against the unpleasant sensations caused by impacts of the blasts on the body is pointed out.
Injury mechanisms and mathematical models as related to both auditory and nonauditory effects are discussed.

K0200

AUTHOR Johnson, D. L. and Patterson, J. Jr.

TITLE Rating of Hearing Protector Performance for Impulse Noise

SOURCE Technical Paper, EG&G Special Projects, Proceedings 1992 Hearing Conservation Conf., Cincinnatti, OH, April 1-4, 1992

ABSTRACT Concern has often been expressed that the performance of hearing protectors in steady noise may not apply to their performance in impulse noise. Our current studies, as well as other studies, support the fact that there is a large difference in performance. In all cases, the performance of a protector is much better for impulse noise than for continuous noise. For example, we are obtaining at least 20 dB of protection for hearing protectors with a Noise Reduction Rating (NRR) of essentially zero. We believe that it is not the NRR procedure at fault; but the fact that, for impulse noise, A-weighting does not discriminate enough against low-frequency energy.

K0201

AUTHOR Richmond, D. R.

TITLE Blast Injuries from the Detonation of Small Charges Inside an Armored Vehicle

SOURCE Draft Preliminary Report, Los Alamos National Laboratory, Kirtland Air Force Base Site, unpublished (undated)

ABSTRACT Introduction: This report gives the results of preliminary tests conducted to select methods of measuring pressure-time, mounting animals, and type of explosives to be used in studies dealing with complex blast waves. The first one of the studies dealing with complex blast waves. The first one of the studies was to measure pressure time in the thorax of sheep exposed to complex blast waves generated by the detonation of small explosive charge inside an enclosure. The data obtained was to be used as input into a mathematical model that calculates the pressure-time pattern in the thorax for ideal blast waves.

The results of the preliminary tests, although very limited, are presented here because they are pertinent to the understanding of the blast overpressure effects on the crews of armored vehicles that are struck with certain warheads. The data are presented in detail because at this time only a limited data analysis was performed and, due to administrative concern regarding the use of animals for tests of this nature, it may be some time before any more tests are conducted.

K0202

AUTHOR Richmond, D. R.

TITLE Bioeffects from Airblasts Entering Enclosures

SOURCE Draft of Personal Paper, unpublished (undated)

ABSTRACT Introduction: The purpose of this brief overview on the effects produced by air blasts entering structures is to point out some of the components in complex blast waves that are associated with injury or noninjury. Although the results apply to a particular set of complex blast waves, they can aid in defining the personnel risk to other sets of complex waves such as those generated by explosions occurring inside an enclosure.

When a blast wave enters a structure or vehicle, its waveform becomes altered. The form that the blast wave takes inside the structure is related to the geometry of the structure, its volume and the area of its openings. The orientation of the openings with respect to the explosion can also be important for some structures. In compiling blast criteria for personnel inside structures, field fortifications have been divided into a number of categories based on the volume of the structure in relation to the area of its openings (volume-to-area ratio); they are foxholes, bunkers, command posts, and shelters. Peak pressures inside these structures can e greater than, equal to, or much less than those the outside waves.

K0203

AUTHOR Richmond, D. R.

TITLE An Estimate of the Blast Effects to Personnel Inside Swedish Field Fortifications on Event Mill Race, Swedish Steel Field Fortifications, Experiment 7001

SOURCE Final Report, Lovelace Biomedical and Environmental Research Institute, for Royal Fortifications Administration, Sweden, December 1981

ABSTRACT Foreword: On behalf of the Defense Nuclear Agency, the Biodynamics Laboratory of the Inhalation Toxicology Research Institute, Lovelace Biomedical and Environmental Research Institute, provided and placed six anthropomorphic dummies inside the Swedish steel fortifications on Event Mill Race. The test was conducted at the White Sands Missile Range, NM. The explosive charge was 600 tons (544 Mg) of ammonium nitrate-fuel oil mixture. The objective of this project was to record the movement of anthropomorphic dummies within the field fortifications and to interpret this movement in terms of estimating the blast displacement effects to personnel. A second objective was to predict the direct overpressure effects to personnel inside the structure from the pressure-time records taken from gauges on he anthropomorphic dummies.

K0204

AUTHOR Richmond, D. R., Yelverton, J. T., and Fletcher, E. R.

TITLE Blast Effects on Crew Personnel, Event Mill Race Experiment 2311

SOURCE Final Report, Lovelace Biomedical and Environmental Research Institute, prepared for Defense Nuclear Agency, Kirtland Air Force Base, NM, 17 February 1982

ABSTRACT Introduction: There is a military requirement for information on (1) the incidence of casualties as a function of vehicular damage and (2) the blast/shock-induced personnel hazards inside manned equipment. This information can be obtained y using anthropomorphic dummies to simulate crew personnel in equipment items exposed either to large high-explosive detonations that simulate nuclear blast or in large nuclear blast simulators such as those located in the United Kingdom and France. This project placed anthropomorphic dummies either inside or adjacent to five Army equipment items tested for their blast hardness on the Mill Race Event by the Nuclear Weapons Effects Laboratory, White Sands Missile Range. The information gained will be added to the data base obtained on Event Dice Throw wherein dummy crew simulators were placed in a variety of armored vehicles and truck-mounted electronic equipment shelters.

K0205

AUTHOR Richmond, D. R., Yelverton, J. T., Fletcher, E. R., Hicks, W., Saunders, K., Trujillo, A.

TITLE Blast Effects on the Crews of U. S. Army Tactical Equipment, Dice Throw Event

SOURCE Project Report, Lovelace Foundation, prepared for U. S. Army Ballistic Research Laboratories, Aberdeen, MD, 1976

ABSTRACT Foreword: This report presents information obtained by the Lovelace Biomedical and Environmental Research Institute in support of U. S. Army projects on Event Dice Throw. Anthropomorphic dummies were placed within U.S. Army equipment items in order to evaluate the blast effects on crew personnel.
The Dice Throw Event was a 600-Ton (ANFO) charge detonated on the surface, October 1976, at White Sands Missile Range, Giant Patriot Site.
The underground command post included in the field test was a coordinated effort. The structure was prefabricated at the Lovelace Foundation and funded by the Defense Nuclear Agency.

K0206

AUTHOR Richmond, D. R.

TITLE Results from Propagation Tests with C-4 Charges, Blast Overpressure-Kirtland Test Site

SOURCE Progress Report, EG&G Mason Research Institute, Western Operations, to U. S. Army Medical Research and Development Command, Ft Detrick, MD, 1989

ABSTRACT Introduction: These tests were conducted in response to a requirement to store as many as 100 ready charges each consisting of 8-lb, uncased, composition C-4. The charges need to be stored close (36 ft) to a firing pad on which they will e detonated one at a time at a rate of one per minute. In order to keep the dimensions of the stored ready-charge array as small as possible, it was necessary to run tests to obtain information that would permit a confirmation of a nonpropagation distance between charges. The information gained would also indicate the better mode of storing the ready charges, I.e., in the ground or hanging in the air.

K0207

AUTHOR Richmond, D. R.

TITLE Blast Protection Afforded by Foxholes and Bunkers - Event Dial Pack

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Proceedings Kolloquim des Fechausschusses I, Probleme des Baulichen Schutes, Weill/Rhein, Germany, pp 11-36, June 1971

ABSTRACT The objective of this project was to obtain information on the amount of protection from the direct blast effects that would be afforded by a 5- x 7-foot bunker and by foxholes of several designs. Specifically, on Event Dial Pack to measure pressure-time histories in full-scale structures for comparisons with those obtained in scale models on a shock tube. Then, to predict the air-blast effects on personnel in these emplacements based on the pressure-time patterns and results of laboratory studies dealing with blast effects near reflecting surfaces and blast effects on rats in scale models of these fortifications.

K0208 DASA-1341

AUTHOR White, C.S., Bowen, I.G., and Richmond, D. R.

TITLE The Environmental Medical Aspects of Nuclear Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, November 1962

ABSTRACT The nature of certain critical lesions seen after exposure to air blast was described and the early lethality characterizing primary and tertiary blast damage was emphasized along with the seriousness of injuries caused by blast-energized debris. Tentative criteria were developed to the end that different levels of environmental variations caused by blast phenomena could be quantitatively related to variations caused by blast phenomena could be quantitatively related to various levels of biological response. Using the "free-field" scaling laws and a mathematical model whereby translational velocities could be computed for animate and inanimate objects, the criteria were applied to nuclear explosions ranging in yield from 1 kt to 100 Mt. Thus, it was possible to specify as a function of yield, the hazard ranges inside which various blast injuries might occur. At these ranges the associated levels of initial nuclear and thermal radiation were computed to allow at least some assessment of the relative importance of all the major hazards from nuclear detonations.

K0209 DASA-1316

AUTHOR Richmond, D. R., Pratt, D. E., and C. S. White

TITLE Oribital Blow-Out Fractures in Dogs Produced by Air Blast

SOURCE Formal Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, April 10, 1962

ABSTRACT Reported here are 11 cases of orbital "blow-out" fractures involving 9 of 115 dogs that were subjected to shock tube-produced air blast.
Usually, there was failure of the frontal, palatine, sphenoid and lacrimal bones--fragments of which were displaced medially and anteriorly into the nasal fossa with extension into the frontal and maxillary paranasal sinuses. In one instance there was extension into the cranial vault. Eye signs, in the form of proptosis of the globe, subconjunctival hemorrhage, ecchymotic areas of the globe and hemorrhage into the intra-orbital soft tissues, were found associated with all cases of orbital fractures.
The pressure-time histories in which animals did nor did not sustain orbital fractures are illustrated along with a tabulation of the corresponding pressure-time parameters. The data indicate that orbital fractures (caused by the eyeball and other intra-orbital tissues hydraulically transmitting the pressure-load to the walls of the orbit more rapidly than counter pressure developed in the air-containing areas bordering the orbit) occurred t maximal pressures above 140 psi provided they reached a peak in less than 30 msec.
The incidence of "blow-out" fractures is discussed along with the significance of this lesion in relation to other blast-produced injuries.

K0210

AUTHOR Richmond, D. R., Goldizen, V. C., Clare, V. R., Pratt, D.E., Sherping, F., Sanchez, R. T., Fischer, C. C., and White, C. S.

TITLE The Biologic Response to Overpressure III. Mortality in Small Animals Exposed in a Shock Tube to Sharp-Rising Overpressures of 3 to 4 msec Duration

SOURCE Technical Paper, Lovelace Foundation, Aerospace Medicine 33: 1-27, January 1962

ABSTRACT A total of 661 young adult animals was utilized in this study, of which there were 240 mice, 60 rats, 177 guinea pigs, and 84 rabbits.
Summary: (1) Four species of animals were exposed, one in a cage, to shock tube-produced, "fast"-rising overpressures of 3 to 4 msec duration primarily to determine the relationship between mortality and the magnitude of the overpressure. (2) The maximal overpressures associated with 50 percent mortality were 29.0, 38.6, 35.2, and 35.6 psi for mice, rats, guinea pigs, and rabbits, respectively.

K0211

AUTHOR Richmond, D. R.

TITLE Notes on the Canadian Biomedical Experiments Carried out in Conjunction with the 100-Ton Explosion at Suffield Experimental Station Near Ralston, Alberta, Canada, Oct 10, 1961

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Minutes of Meeting, Tripartite Technical Cooperation Program, 14-15 March 1963

ABSTRACT There were 45 goats, 60 rabbits, 240 mice and 310 rats exposed at various distances between 270 ft and 820 ft from a 100-ton surface burst of TNT.
Except for 5 goats and 90 rats located in field shelters, all the animals were in individual cages that were placed on the ground's surface. Seventeen goats were killed by the air blast at 30 psi and above of which 14 were in cages on the surface and 3 were in the field shelters. The field shelters evidently did not afford adequate protection to the goats against air blast. Except for a single 4-hr death all the goats were dead by 30 min postshot when personnel entered the area. The goat LD50 at one hour in terms of the estimate incident shock pressures was calculated by probit analysis to be 34.9 psi with 95 per cent confidence limits of 31.0-42.5 psi.
Flying debris in the form of clumps of earth crushed many of the small animal cages which, along with the many apparent heat deaths caused by the sun, ruined the small animal portion of the experiment.
All of the 45 goats were subjected to post mortem examination. The gross pathological findings were reported and discussed.
The tolerance of the goat obtained on the 100-ton blast was compared to other values in the literature obtained with short duration HE pulses and with long duration shock tube reflected pressures.

K0212

AUTHOR White, C. S., Bowen, I. G., and Richmond, D. R.

TITLE Comments on CDOG Study No., USACDCNG 62-8, Criteria for Nuclear Weapon Personnel Casualties

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, submitted to Defense Atomic Support Agency, Washington, DC, August 3, 1963

ABSTRACT Introduction: At the request of Captain Lawrence H Putman, USA, Armor, Combat Operations Division, Nuclear Group, United States Army Combat Development Command, Ft Bliss, TX, a document designated as CDOG Study No. USACDCNG 62-8 and entitled "Criteria for Nuclear Weapon Personnel Casualties" was reviewed and comments prepared. These, limited mostly to the area of blast biology and related matters, are presented below in out line form, following the page and section sequence of the 62-8 manuscript.

K0213

AUTHOR White, C. S., Bowen, I. G., and Richmond, D. R.

TITLE Canadian Biomedical Experiments Proposed for 100 Ton TNT Explosion

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support, Washington, DC, 27 July 1961

ABSTRACT This report concerns Canadian plans for biomedical experiments proposed present as a part of the blast and shock program to be carried out on the 100-ton TNT explosion scheduled for August 1961 in Ralston, Alberta, Canada. Included are copies of (a) the correspondence received by the Lovelace Foundation from the Suffield Experimental Station, Ralston, Alberta, requesting an opinion and advice regarding tentative plans for exposing experimental animals, and (b) the material prepared in reply.
The data, since they reflect portion of the current, "state-of-the-technical-art" in the area of biological blast research, will interest those who desire quantitative information on the extrapolation of animal data to predict the tolerance of man to blast-produced pressure phenomena; the techniques used in exposing animals in sock and blast experiments; the importance of the geometry of exposure and instrumentation to record the environmental pressure-time variations at or very near biological targets; the need to segregate effects due to pressure, missiles, and displacement; the currently available means for predicting displacement time, velocity-time, and g-time anticipated for animate and inanimate objects exposed to blast pressures and winds as these parameters vary with range; explosive yield, wave form; and interspecies mortality-time data applicable to "fast"-rising overpressures on the one hand and violent impact on the other.

K0214

AUTHOR White, C. S.

TITLE Biological Blast Effects, Statement of Dr. Clayton S. White, Director of Research, Lovelace Foundation for Medical Education and Research, Albuquerque, NM

SOURCE In Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the US, Eighty-Sixth Congress, First Session on Biological and Environmental Effects of Nuclear War, Part pp 311-372, US Gov Print Off, 1959

ABSTRACT Introduction: This presentation, though generally concerned with biological effects of airborne blast phenomena, will be limited to deal briefly with three main topics First, the scope and nature of the several blast hazards will be delineated. Secondly tentative criteria for threshold damage to humans will be set forth. Thirdly, these criteria will be related to nuclear weapons in terms of ground ranges and area involved for 1 MT and 10 MT surface detonations, and to allow appreciation of the relative importance of blast with other effects, appropriate values for ionizing and thermal radiation will be noted.

K0215

AUTHOR Richmond, D. R., Wetherbe, M.B., Taborelli, R. V., Chiffelle, T. L. and White, C. S.

TITLE The Biologic Response to Overpressure I. Effects on Dogs of Five to Ten-Second Duration Overpressures Having Various Times of Pressure Rise

SOURCE Reprint Lovelace Foundation for Medical Education and Research, in J of Aviation Medicine 28: 447-460, October 1957

ABSTRACT Summary: A versatile and relatively simple laboratory means of creating various patterns of environmental variations in pressure was described, and selected pressure-time records were presented to illustrate the conditions of exposure of experimental animals (dogs) to long duration overpressures (5 to 20 sec). Exposure conditions with and without a wind baffle were arranged such that the significant variable in the pattern of the environmental pressure variations for the nondisplaced animals was alteration in the rise times of the several pressure pulses which ranged from 27 to 158 milliseconds. The falling phase of the pressure pulse was between 5 and 20 seconds and was sufficiently slow as to be nondamaging alone.

Fatalities were limited to animals subjected to dynamic decelerative loading subsequent to displacement when no wind baffle was employed as protection against high velocity winds. Gross pathology in nondisplaced, but restrained animals, even though exposed to overpressures ranging from 60 to 170 psi, was limited to eardrum failure, sinus and middle ear hemorrhage, laryngeal petechiae and characteristic marginal, wedge-shaped hemorrhagic lesions of the costophrenic portions of the lung bases.

The general problem of understanding biologic response to environmental overpressure was discussed and emphasis was placed on the necessity of considering all parameters of the pressure-time variation whether these be single or multiple pulses involving stepwise or saw-tooth variations in the rising and falling phases of short or long duration pressure phenomena. Particular attention was directed to the potential significance of the falling phase of the fill time of the lung and allows charging of the blood with high pressure gas.

K0216

AUTHOR Richmond, D. R., Clare, V. R., Goldizen, V. C., Pratt, D. E., Sanchez, R. T. and White, C. S.

TITLE Biological Effects of Overpressure II. A Shock Tube Utilized to Produce Sharp-rising Overpressures of 400 Milliseconds Duration and Its Employment in Biomedical Experiments

SOURCE Reprint, Lovelace Foundation for Medical Education and Research, Albuquerque, NM, Aerospace Medicine 32: 997-1008, November 1961

ABSTRACT Summary: A shock tube employed for blast biology studies is described along with the results of one series of experiments.

The shock tube is air-driven and utilizes Mylar plastic diaphragms. The compression chamber is 17.5 ft in length and 40.5 inch I.D.; it reduces in diameter to 23.5 inches over a 3-foot-long transition section just upstream of the diaphragm station. The expansion chamber consists of 30 feet of 23.5 inch I.D. tubing followed by 22 feet of 40.5 inch I.D. tubing. It is closed distally by a steel end-plate to generate high pressures from the reflected shock. Three vents in the expansion side of the system serve to control the duration of the overpressure and to eliminate multiple reflections by bleeding off the reflected shock as it travels upstream.

An interspecies correlation is presented based on mortality data from six species of experimental animals with an extrapolation to a 70 kg animal.

K0217 AECU-3350

AUTHOR Bowen, I. G., Richmond, D. R., Wetherbe, M. B., and White, C. S.

TITLE Biological Effects of Blast from Bombs. Glass Fragments as Penetrating Missiles and Some of the Biological Implications of Glass Fragmented by Atomic Explosions

SOURCE Progress Report, Contract AT(29-1)-1242, Lovelace Foundation, Albuquerque, NM, prepared for U.S. Atomic Energy Commission, Division of Technical Information, Oak Ridge, Tenn, June 18, 1956

ABSTRACT Abstract: An exploratory study was made whose aim was to evaluate the damage done by low velocity (less than 1000 ft/sec) missiles consisting of small fragments of ordinary window glass striking in random orientations a biological target. The index of damage was chosen to be the penetration of the abdominal wall of anesthetized dogs. By use of appropriate laboratory data criterion of penetration was derived which expresses in equation form the probability of penetration in terms of missile mass and impact velocity.
The penetration criterion was applied individually to data for 2486 glass missiles originating in test houses placed on Operation Teapot at various ranges from ground zero.
By use of other statistical procedures, expectation of penetration was computed as a function of overpressures for the region between 1.9 and 5.0 psi. It was found that maximum expectation occurred at about 2.8 psi.
The general biological significance of the results obtained was discussed.

K0218

AUTHOR White, C.S. and Bowen, I. G.

TITLE Comparative Effects Data of Biological Interest

SOURCE Progress Report, First Draft, Contract AT(2901)-1242 Lovelace Foundation for Medical Education and Research, Albuquerque, NM, Div of Biology and Medicine, U.S. Atomic Energy Commission, Wash., DC, 10 Apr 1959

ABSTRACT Introduction: In the material that follows selected weapons effects data have been assembled for quick reference as an aid to those interested in the physical and biological effects of nuclear weapons. The quantitative data have been preceded by two sections chosen to facilitate orientation of the reader. The first contains brief definitions of the terminology employed throughout the brochure and the second deals grossly with the physical and biological consequences of the several environmental variations created by nuclear explosions. Such information will foster appreciation of the comparative ranges for the major effects as these vary with explosive yield and as these contribute to the total hazard man.
It is well here to point out that the values for any given effect can vary considerably depending on many factors not the least of which are weapon design and yield, location of burst, weather, terrain, and range from the detonation. Even tough the numbers chosen are the outcome of theoretical and full-scale studies in which many uncertainties were appreciated, they nevertheless represent best approximations which are probably accurate within plus or minus 10-30 per cent and hence are reasonably valid for the purposes of orientation and protective planning.

K0219

AUTHOR White, C. S.

TITLE Biological Tolerance to Accelerative Forces, Addendum I

SOURCE Convair Aeromedical Consultant's Report, Lovelace Foundation for Medical Education and Research, Albuquerque, NM, 17 June 1954

ABSTRACT Summary: 1. Data were presented graphically showing the relative G loads imposed by automobile accidents, catapults, parachute opening and landing shocks, ejection seats and the tolerance of the human head protected with crash helmets to impact loads. 2. A brief letter report dealing with the actuation of ejection seat controls when subjects were exposed to radial G along with pitch and roll was presented. 3. The effect of G loads on a man's ability to move was covered. Forces of 3 to 4 G when properly directed were near the limit against which the body extremities could be moved, which would allow progression from one point to another and which prevented rising from an aircraft seat. G loads between 1 and 3 G significantly increase the time to perform a given task; e.g., donning a backpack parachute took 17 seconds at 1 G gravity load; time increased to 21, 41, and 75 seconds at a radial G load of 1, 2, and 3 G, respectively. The task was impossible for some subjects. 4. Difficulties with orientation and vision occurred when subjects were exposed to "jostle" in a radial G field. Nausea was experienced and post-exposure effects were noted for 2 hours after a 10 minute exposure to a 1.14 resultant G force when head movements and up and down bouncing was carried out during the exposure on the centrifuge.

AUTHOR White, C. S.

TITLE The Nature of the Problems Involved in Estimating the Immediate Casualties from Nuclear Explosions

SOURCE Lovelace Foundation for Med. Ed. & Res., summarized before The Conference on Disaster Medical Care, American Medical Association Committee on Disaster Medical Care/Council on National Security, Albuquerque, NM, November 15, 1968

ABSTRACT It was pointed out that considerable progress has been made in assembling range-yield-effects data for nuclear detonations applicable to a variety of burst conditions and that tentative tough incomplete biomedical criteria have been formulated for assessing the hazards of exposure to last as well as ionizing and thermal radiations. Even so, it was noted that great care must be taken if meaningful concepts are to come from a combined use of the physical and biomedical data.

In emphasis of this fact, the physically and biologically oriented problem areas were presented and discussed. Also, survival data for he Hiroshima explosion were used to show that the conditions for exposure more than any other factors determined immediate survival and ore than anything else was responsible for keeping the casualty figures as low as they were.

A major deterrent in applying the experience in Japan to a more generalized situation is the lack of information about the differences between "free-field" parameters and the environmental varistors that will actually occur at the locations of people immediately following the burst. The relevant problems are complex and difficult and there has been neither widespread appreciation to the need to "move out of the streets and into exposure locations" nor with one exception much progress in translating "free-field dose" to "exposure dose" at locations of interest. The exception is the Ichiban I Program being carried out cooperatively by personnel from Oak Ridge National Laboratory and the Atomic Bomb Casualty Commission.

A second difficulty in generalizing across the range-yield spectrum of effects is the fact that, all other things being the same, the ratios of major effects parameters to one another change with yield; viz., the range-yield-effects curves for thermal and ionizing radiation and for blast are not parallel with one another.

Even so, tentative biomedical criteria can be combined with range-effects data for different yields and burst conditions to define the ranges inside which and the area over which specified potential hazards exist. Also, given a completely flat terrain, the absence of structures and all people exposed in the open, casualty estimates for such "free-field" exposure conditions might perhaps be credible. In the presence of terrain variations and the many types for buildings in cities and urban complexes, there can be no satisfactory predictions until positional, geometric and orientational factors along with others defining the conditions of exposure have been recognized and assessed. The state of the art currently does not include this sophistication and any but the greatest estimation of nuclear casualties is hardly possible today.

K0221

AUTHOR Damon, E. G., Gaylord, C. S., Richmond, D. R., and White, C. S.

TITLE The Effects of Shock-Tube-Generated Air Blast on Guinea Pigs Mounted in Model Foxholes of Various Design

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, August 1967 (unpublished)

ABSTRACT Effects of the geometry of exposure on tolerance of guinea pigs to air blast were exposed. A total of 580 guinea pigs was subjected to shock-tube-generated air blast while mounted in model foxholes of the following designs: shallow, simple deep, deep with a body-width offset at the bottom, deep with a body-width offset in the middle, and deep with a body-length offset near the bottom of the chamber. The animals were placed head-on, tail-on, and side-on the incident shock in the various chamber geometries.

Results that have been previously reported on the exposure of 118 additional animals in three different geometrical arrangements were also reviewed for comparative purposes.

The LD50/24-hours, in terms of the incident shock pressures measured adjacent to the chambers, were calculated for each arrangement by probit analysis. The results showed that the deep chambers with mid-offsets and those with long-offsets generally offered more protection than did the shallow foxholes The simple deep chambers and the deep chambers with bottom-offsets afforded the least protection. In most cases, the animals exhibited greater tolerance when the chambers were oriented side-on to the incident shock than when end-on. In the deep chambers, the animals showed less tolerance when they were exposed tail-on than when head-on.

The forms of he incident shock waves, as recorded from gauges in the wall of the shock tube, were altered upon entering the various types of deep chambers. The maximal pressures, s recorded from gauges positioned hear the thoraces of the animals in the chambers, were generally higher and the rise-times to maximum were generally longer than for the incident shocks. The relations of the various "non-ideal" blast waveforms to the blast tolerances exhibited by the animals in the different exposure arrangements are discussed.

K0222

AUTHOR White, C. S.

TITLE Rationale of Treatment of Primary Blast Injury to the Lung

SOURCE Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, June 1968 (presented at the Panel N-5, Effects on Personnel, Technical Cooperation Program, Brooks AFB, TX, May 1968

ABSTRACT As a background for better understanding the nature of direct blast injury to the lungs, the implosion process was described as were other important events which follow the impact of a blast wave with the body wall. Therapy was selectively discussed, and where available, new data broadening the physicians' regimen for patient care were presented.

K0223 DASA-1857

AUTHOR Bowen, I. G., Fletcher, E.R., Richmond, D. R., Hirsch, F. G., and White, C. S.

TITLE Biophysical Mechanisms and Scaling Procedures Applicable in Assessing Responses of the Thorax Energized by Air-Blast Overpressures or by Non-Penetrating Missiles

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prpeared for Defense Atomic Support Agency, Washington, DC, November 1966

ABSTRACT A mathematical model was described which was devised to study the dynamic response of the thorax of mammals to rapid changes in environmental pressure and to non-penetrating missiles impacting the rid cage near the mid-lateral point of the right or left thorax. Scaling procedures for similar animalswere describing relating, for a given degree of damage, the body mass of the animal to various parameters describing the exposure "dose."
Internal pressures computed with the model for a dog exposed at the end plate of a shock-tube were compared to those measured with a pressure transducer inserted in the esophagus down to the level of the heart.
Computed time-displacement histories of missiles following impact with the right side for he thorax were compared to those obtained experimentally by means of high-speed motion picture photography. High internal pressures predicted with the model for non-penetrating impact were compared to those obtained experimentally and theoretically for exposure to air blast.
Experimental data were presented arbitrarily assess lung damage in animals struck by non-penetrating missiles (constant impact area) as a function of missile mass and impact velocity. These data were compared for several missile mass-velocity combinations with those computed sing the mathematical model. Similarities in the dynamic responses of the thorax to air blast and to non-penetrating missiles were discussed.

K0224

AUTHOR Richmond, D. R., Taborelli, R. V., Sherping, F., Wetherbe, M. R., Sanchez, R. T., Goldizen, V. C., and White, C. S.

TITLE Shock Tube Studies of the Effects of Sharp-Rising, Long-Duration Overpressures on Biological Systems

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, in Proceedings of Third Shock Tube Symposium, pp 171-189, Air Force Special Weapons Center, Kirtland AFB, NM, 10-12 March 1959

ABSTRACT Introduction: Shock tubes have been successfully by a number of investigators to study the biological effects of variations in environmental pressures Recently an unusually versatile laboratory pressurization source became available with the capability of consistently reproducing a wide variety of pressure-time phenomena of durations equal to and well beyond those associated with the detonation of nuclear devices. Thus, it became possible to supplement costly full-scale field research in blast biology carried out at the Nevada Test Site by using an economical yet realistic laboratory tool. In one exploratory study employing pressure pulses of 5 to 10 msec duration wherein the times to max overpressures and the magnitudes of the overpressures were varied, a relatively high tolerance of biological media to pressures well over 150 psi was demonstrated. In contrast to long duration overpressures in which the pressure rises occurred in single and double fast-rising steps.

K0225

AUTHOR White, C. S.

TITLE Tentative Biological Criteria for Estimating Blast Hazards

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Proc. Symp. on Protective Structures for Civilian Populations, pp 41-4, April 1965, Nat. Acad. Sci., National Research Council, Wash, DC (see also CEX 65.4)

ABSTRACT Introduction: This presentation will attempt to deal with three related areas in a reasonably systematic way as follows. First, the nature of the blast-related phenomena that may be significant to occupants of protective structures will be noted and categorized. Also, relevant information from field studies will be reviewed.
Second, criteria for estimating human hazards from such phenomena will be presented even tough those available are tentative and incomplete and only a beginning has been made in their formation.
Third, supporting material and references for the literature, including those from a long-term, continuing program sponsored by the Division of Biology and Medicine of the U.S.. Atomic Energy Commission since 1951, and by the Defense Atomic Support Agency of the Department of defense since1959, will be summarized briefly. Such information will aid those who would need to understand the tenuous nature of the criteria and better appreciate the intraspecies biological studies, as well as the elated biophysical and physical investigations that have not only improved understanding of the effects of blast from conventional explosives, but also extended the data to include nuclear blast as well.

K0226 CEX-65.4

AUTHOR White, C. S., Bowen, I. G., and Richmond, D. R.

TITLE Biological Tolerance to Air Blast and Related Biomedical Criteria

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, prepared for Civil Effects Branch, Division of Medicine, U. S. Atomic Energy Commission, Washington, D. C.

ABSTRACT Experience with animals exposed in a variety of above and below ground structures during full-scale field operations at the Nevada Test Site in 1953, 1955 and 1957 were reviewed. The data were assembled and summarized to illustrate the nature of the blast-induced problems of significance in protective shelters, "open" and as well as "closed." Potential hazards were related to the following: various patterns of variation in environmental pressure; translational events associated with transient, high-velocity winds, ground shock and gravity involving the impact of energized in animate objects on the one hand and the consequences of whole-body displacement on the other; non-line-of-site thermal phenomena included hot objects and rapidly moving hot, dust-laden and debris; and dust, in the respirable size range, sufficiently high in concentration even in "closed" shelters as to warrant design measures to minimize or eliminate the occurrence of small particulates whether arising from wall spalling or otherwise. Tentative biological criteria, conceived to help assess human hazards from blast related phenomena, were presented. Relevant data from the literature and on-going research in environmental medicine were set forth to aid the reader in appreciating how the criteria were formulated, what information was extrapolated from animal data, and wherein "best estimates" were employed. "State-of-the-art" concepts were noted to emphasize areas in which more thinking and research must continue if more refined, complete and adequate criteria are to be forthcoming for assessing man's response to blast-induced variation in his immediate environment.

K0227

AUTHOR Richmond, D. R., Damon, E. G., Betz, P. A., and White, C. S.

TITLE The Effects of Blast and Ionizing Radiation in Rats

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, for Defense Atomic Support Agency, Washington, DC, June 1965.

ABSTRACT Two hundred and eighty rats were divided into four groups and subjected to a near LD50/30-day level of 25 kvp xrays followed by an LD5-30-day dose of airblast on days 1 and 7. An additional 40 rats served as controls A synergistic effect was noted in the animals blasted seven days following radiation exposure in terms of 30-day lethality and in the number of early and delayed deaths.
At the dose levels employed, the 30-day lethality for rats radiated and blasted on the same day were simply additive. Previous work on combining whole-body radiations and blast were discussed.

K0228

AUTHOR Damon, E. G., Gaylord, C. S., Yelverton, J.T., Richmond, D. R., Bowen, I. G., Jones, R. K., and White, C. S.

TITLE Effects of Ambient Pressure on Tolerance of Mammals to Air Blast

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, in Aerospace Medicine, 19(10): 1039-1047, October 1968

ABSTRACT Dogs, goats, rats, and guinea pigs were exposed against the end plate closing the expansion chamber of a shock tube to air blast at ambient pressures (P1) ranging from 5 to 42 psia. As previously found with mice, animal blast tolerance, expressed at delta P50-one-hour reflected overpressures, rose progressively as the experimental ambient pressure was increased. When expressed as the ratio, delta P50/P1, the median lethal dose tended to fall at the higher ambient pressures.
A set of equations relating air blast tolerance to the ambient pressure at exposure was derived for five species of mammals and by use of these and other results a similar equation was obtained for predicting the effects of ambient pressure on human tolerance to air blast.

K0229 POR-7013-2

AUTHOR Fletcher, E. R., Yelverton, J.T., and Richmond, D. R.

TITLE Personnel Protection, Event Misers Bluff

SOURCE Final Results Report, Lovelace Biomedical and Environmental Research Institute, in Proceedings, Misers Bluff Results Symposium, Phase II, 27-29 March 1979, Vol II/III, pp 4-295 through 4-322, 26 Sep 79

ABSTRACT Introduction: The objective of this project was to determine the protection from airblast displacement afforded personnel inside fighting bunkers and slit trenches. This was to be accomplished by (a) measuring the time-displacement histories of two anthropomorphic dummies standing inside a 91x183x183-cm fighting bunker oriented with the firing port side-on to the blast; (b) using these data to confirm predictions made with a previously developed mathematical model; and (3) comparing the blast displacements of dummies prone on the surface with those in slit trenches.

K0230

AUTHOR Richmond, D. R., Yelverton, J. T., and Fletcher, E. R.

TITLE Far-Field Underwater Blast Injuries Produced by Small Charges

SOURCE Final Technical Report, Lovelace Foundation for Medical Education and Research, prepared for U.S. Navy Bureau of Medicine and Surgery (BUMED 7111), U.S. Naval Ordnance Laboratory, Silver Spring, MD, December 1972

ABSTRACT Underwater blast injuries, at increasing ranges beyond the lethal zone from small charges, were studied using animals. The study was conducted in an artificial pond that measured 220 x 150 ft at its surface. The pond was 30 ft deep over its 30- x 100-ft center portion. Sheep, dogs, and a few monkeys were exposed to the blast oriented vertically in the water (long axis perpendicular to the surface). Most were exposed to the blast at 1-ft depths, heads above the surface, and a limited number at 2- and 10-ft depths. Explosive charges were mostly bare spheres of Pentolite weighing 0.5, 1, 3, and 8 lb. All charges were detonated at 10-ft depths. The emersion-blast injuries were of minor severity and consisted mainly of lung hemorrhages and small areas of contusions in the gastrointestinal tract. The incidence and severity of the injuries were correlated with the impulse in the underwater blast wave. Tests were run with dogs beneath the surface to evaluate eardrum rupture. The subjects were right-side-on to the blast and a probit analysis run on the data for the right ears yielded an impulse of 22.6 psi.msec of 50-percent eardrum rupture. Based on the results of this study, a safe impulse level of 2 to 3 psi.msec for unprotected swimmers, head above the surface, was proposed. This safe impulse level was discussed in relation to the underwater blast wave parameters in the test pond and existing response data for personnel.

K0231

AUTHOR Yelverton, J. T., Richmond, D. R., Fletcher, E. R., and Jones R. K.

TITLE The Effects of Underwater Explosions on Birds

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Nuclear Agency, Washington, DC, February 1973

ABSTRACT A study was conducted to determine the response of birds to underwater blast. The tests were performed in a fresh water pond with surface dimensions of 220 x 150 ft. The pond was 30-ft deep over its 100- x 30-ft center portion. Both 1- and 8-lb TNT charges were used. Lethality and the incidence and severity of injuries were correlated with the impulse of the underwater blast wave.

Rouen and Mallard ducks were used as models for swimming and diving birds. The birds were tested on the water surface and at 2-ft depths. The study demonstrated that submerged animals are more vulnerable to underwater blast than those on the surface.

Results from the experiment with ducks at 2-ft depths indicated that: (1) an impulse of 44.7 psi.msec would produce severe injuries and a 50-percent incidence of deaths, (2) slight to severe injuries and a 1-percent mortality were associated with a 36.3 psi.msec impulse, and (3) no injury would result from a 5.7 psi.msec exposure.

The results of the surface tests demonstrated that (1) an impulse of 129 psi.msec or more is required to kill a bird on the surface, and (2) there should be no injuries resulting from exposure to impulses of less than 34 psi.msec.

Curves were prepared to scale the impulse endpoints arrived at in this study to other weights of charges and charge-target depth configurations.

K0232

AUTHOR Slifko, J. P.

TITLE Shockwave Results from Underwater Explosion Tests Conducted by Lovelace Foundation for Medical Education and Research

SOURCE Internal Memorandum, U.S. Naval Ordnance Laboratory, Silver Spring, MD, 21 Aug 1970

ABSTRACT The Lovelace Foundation for Medical Education and Research has obtained pressure-time histories from 1/8-lb and 8-lb spherical pentolite charges fired in their test pond. These data were obtained in conjunction with underwater blast studies with animal targets. At the conclusion of these tests, free-water shockwave measurements were made without the animals and rig in the water. The shockwave results of these two sets of measurements differ and are compared with the pentolite similitude values established by the Naval Ordnance Laboratory.

K0233

AUTHOR Richmond, D.R.

TITLE Underwater Blast Studies

SOURCE Draft copy of presentation, Lovelace Biomedical and Environmental Research Institute, undated.

ABSTRACT Introduction: In this presentation I would like first to show you a film of some test operations wherein sheep were exposed to underwater blast in our test pond. They were tested on the surface, heads above water, at 3.3 m depths. Then, I will give the results in terms of isoimpulse-curves relating specific damage levels to range and charge weight. This will be followed by slides showing the nature of underwater blast injuries, and finally, the underwater blast waves evaluated by an unprotected swimmer (software) in various charge-target configuration.

K0234

AUTHOR Richmond, D. R., Yelverton, J. T., Gaylord, C. S., and Fletcher, E. R.

TITLE Underwater Blast Studies With Animals

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Explosions Research Department, US Naval Ordnance Laboratory, Silver Spring, MD, February 1970 (unclassified formerly Confidential)

ABSTRACT Two hundred and forty-two sheep were subjected to underwater blasts in a specially constructed pond (220 ft long x 150 ft wide x 30 ft deep). Animals were located at selected ranges from the charges in order to determine the distances where 50% mortality occurred. In Experiment 1, 120 sheep were tested at 1- and 10-ft depths to the blasts from 1- and 8-lb charges detonated at 2.5- and 10-ft depths. In Experiment 2, 71 sheep were exposed at 1-ft depths to blasts from 0.5, 0.25, and 0.125-lb charges at 2.5-ft depths of burst. In Experiment 3, sheep were located at 20-ft depths with 1- and 8-lb charges fired at 10-ft depths. It was possible to bracket the LD50 ranges in 12 of the 13 charge-target configurations.

Pressure-time was recorded at each of the animal locations. Peak pressure, impulse, energy, theta and duration values were compiled using a computer. Impulse levels provided the best fit to the mortality data. The mean impulses corresponding to the 50% an 1% lethal ranges were 87.0 and 59.2 psi.msec, respectively.

The results of a few checkout tests (Experiment 4) showed that the response of 70-kg sheep to the underwater blast was the same as that of the 40-kg sheep used in the three major tests; dogs and monkeys sustained the same form of injuries as did the sheep; and the bubble pulse rising from 1-lb charges at a burst depth of 15 and 20 ft did not add to the injuries sustained by sheep at 1-ft depths exposed directly above the charges.

The results were discussed in relation to casualty criteria for personnel in the water.

K0235

AUTHOR Bowen, I. G.

TITLE Translation Effects Criteria

SOURCE Illustrative material and notes, Lovelace Foundation for Medical Education and Research, presentation before Subcommittee on Blast and Thermal, Advisory Committee on Civil Defense, National Academy of Sciences, Washington, D. C., Aug 1967

ABSTRACT A. Translation experiments in UK 3.7 shelter on Priscilla Shot, and related material. B. Translation model and window-glass fragment experiments on Galileo Shot. C. Decelerative tumbling-block wall on Galileo Shot. D. Dummy experiments, Priscilla and Smoky Shots. E. Dummy and goat experiments, Snow Ball.

K0236 NSWC TR 82-326

AUTHOR O'Keeffe, D. J.

TITLE Guidelines for Predicting the Effects of Underwater Explosions on Swimbladder Fish

SOURCE Technical Report, Research and Technology Department, Naval Surface Weapons Center, Dahlgren, VA, 29 March 1984

ABSTRACT This report is a guide for predicting the effects of underwater explosions on swimbladder fish. Computer calculations hae been made covering a wide range of fish sizes, explosive charge weights, and depths of burst. Contour plots of kill probability are presented along with equations depicting maximum range in terms of charge weight. A criterion is established which should aid in minimizing fish-kill, and an upper limit is set on the lateral extent of kill for a given charge weight.

K0237 NSWC TR 81-149

AUTHOR Goertner, J. F.

TITLE Fish-Kill Ranges for Oil Well Severance Explosions

SOURCE Technical Report, Naval Special Weapons Center, White Oak, Silver Spring, MD, April 1981

ABSTRACT Computations based on the extreme values of compression and extension of the fishes' swim bladder in response to the explosion pressure field were used to estimate lethal ranges from wellhead severance explosions. The computations were done using an equivalent-weight bare charge in free water which was matched to measured data -- shockwave peak pressure, decay constant and impulse -- from a 1/2-scale wellhead-model explosion test. Results are x,y-contour plots of 10%, 50% and 90% kill probability for 1-ox, 1-lb and 30-lb swimbladder fish in water 200, 500, and 1000 feet deep.

K0238 NSWC/WOL/TR 76-92

AUTHOR Gaspin, J. B.

TITLE Safe Delivery Ranges for Swimmer-Launched Weapons

SOURCE Technical Report, Naval Surface Weapons Center, White Oak, Silver Spring, MD 20910, 31 August 1977

ABSTRACT This report presents the results of a preliminary study of safe delivery ranges for a swimmer-launched, self-propelled, standoff weapon. The problem of a charge exploding in contact with a ship hull in shallow water is considered in terms of swimmer safety. Previous free-water safe swimmer ranges are modified to account for shock wave-hull interactions and bottom reflections. Refraction is discussed. Simple conservative approximations are used, and worst-case swimmer safe ranges are calculated. These ranges are 200 to 400 percent greater than those calculated for infinitely deep unobstructed water. In general, the safe ranges are found to be smaller in shallower water than in deeper water.

K0239 3552(02)FR

AUTHOR Moore, D. B., Anderson, M. C., and Huber, G. B.

TITLE Addendum to the Final Report for a Feasibility Study of an Underwater Severance System for Personnel Egress, Appendix A. Lovelace Research Insitute Report of Live Animal Tests... ----

SOURCE Final Report, Appendix A. Lovelace Research Institute Report of Live Animal Tests with Type III Underwater Panel Severance Test Assemblies, Explosive Technology, Fairfield, CA, prepared for Naval Ordnance Station, Indian Head, MD, December 1976

ABSTRACT Two type III assemblies were manufactured and shipped to Lovelace. Six sheep were used. Three sheep were positioned with their backs at approximately 6 to 12 inches from the explosive charges. They were immersed with their neck line near the same level as the upper leg of the explosive charge. Three sheep were positioned with their sides within approximately 3 inches of the explosive charge. Post-shot visual and autopsy examinations were performed with the highly favorable results quoted in Appendix A.

K0240 USAARL 94-2

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies With Animals and Men: A Walk-Up Study

SOURCE Final Report, Contract DAMD-17-88-C-8141, EG&G Special Projects, prepared for U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, September 1994

ABSTRACT The U.S. Army needs realistic safe limits for exposure to impulse noise produced by heavy weapons. Impulse noise limits, based on data from small arms, maybe overly conservative. In order to define new limits for heavy weapons, this systematic 5-year stud of the effects of high-intensity impulse noise on human volunteers was undertaken. The number of impulses, the peak pressure levels, and spectral distributions of energy of heavy weapon-like impulses were varied systematically. Five major groups of 273 volunteers were given a series of exposures to one of three impulse types and to three types of hearing protection. The impulse spectrum was varied by changing the distance between the volunteer and an explosive detonation. The peak pressure level was varied in 3-dB steps by changing the weight of the explosive charge. The number of impulses per day was 6, 12, 25, 50, or 100. Volunteers wore hearing protection for all exposures. After each exposure, the amount of TTS, if any, was determined. Each volunteer started with an exposure of six impulses at the lowest intensity. If the TTS was less than 15 dB, the subject received six impulses at the next higher level the next day. This continued through all intensities. Then, the number of impulses was increased using the maximum intensity permitted by nonauditory injury limits. The first group used an earmuff with maximum intensity permitted by nonauditory injury limits. The first group, using an earmuff as a protective device, completed all exposures. The peak sound pressure levels varied from 172 to 191 dB with an A-duration of approximately 3 ms. No significant TTS (in excess of 25 dB) was observed for any condition.
The second group, using an earmuff with controlled leaks, completed the same exposures as the first group. In this case, only one of 65 subjects had a significant TTS. This was from 100 shots at 191 dB. Using the same protection, the third group was exposed to impulses with peak levels from 178 to 196 dB and with an A-duration of 800 seconds. A considerable number of subjects had significant TTS once the peak level exceeded 187 dB. Continuing with the same leaking muff, the fourth group was exposed to impulses whose peak SPL varied from 175 to 193 dB and whose average A-duration was 1.5ms. Again, there were cases of significant TTS once the peak level exceeded 187 dB. Using the impulses of group 4, the final group was tested with earplugs with a hole through them. Compared to the leaking muffs, these plugs were completely unsatisfactory. Except for the perforated plugs, the majority of the subjects were willing to be exposed up to the threshold set by nonaudutiory considerations. Results of acceptability questionnaires and medical examinations are also included.

K0241

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups DBC and DBD, 1 Meter Distance, Modified Muff, Sep-Oct 91)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, Nov 91

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups DBC and DBD, 1-m distance, condition D, of 12 volunteer subjects that arrived by 15 September 1991. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 178 dB (Level 1) to 196 dB (Level 7). The A-duration was approximately 0.8 msec. The modified (eight tubes were put through the seal) RACAL muff was used as a protective device.

K0242

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups DCE and DCF, 1 Meter Distance, Modified Muff, Nov-Dec 1991)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, January 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups DCE and DCF, 1-m distance, condition D, of 12 volunteer subjects that arrived by 4 November 1991. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 178 dB (Level 1) to 196 dB (Level 7). The A-duration was approximately 0.8 msec. The modified (eight holes were put through the seal) RACAL muff was used as a protective device.

K0243

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups DAA and DAB, 1 Meter Distance, Modified Muff, August 1991)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, September 1991

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups DAA and DAB, 1-m distance, condition D, of four volunteer subjects that arrived by 22 July 1991. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 178 dB (Level 1) to 196 dB (Level 7). The A-duration was approximately 0.8 msec. The modified (eight tubes were put through the seal) RACAL muff was used as a protective device.

K0244

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups DDG and DDH, 1 Meter Distance, Modified Muff, Jan-Feb 1992)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, March 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups DDG and DDH, 1-m distance, condition D, of 12 volunteer subjects that arrived by 2 February 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 178 dB (Level 1) to 196 dB (Level 7). The A-duration was approximately 0.8 msec. The modified RACAL muff was used as a protective device.

K0245

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups DEI and DEJ, 1 Meter Distance, Modified Muff, Mar-Apr 1992)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, May 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups DEI and DEJ, 1-m distance, condition D, of 13 volunteer subjects that arrived by 2 February 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 178 dB (Level 1) to 196 dB (Level 7). The A-duration was approximately 0.8 msec. The modified RACAL muff was used as a protective device.

K0246

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups DFK and DFL, 1 Meter Distance, Modified Muff, June-July 1992)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, July 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups DFK and DFL, 1-m distance, condition D, of 12 volunteer subjects that arrived by 10 May 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 178 dB (Level 1) to 196 dB (Level 7). The A-duration was approximately 0.8 msec. The modified RACAL muff was used as a protective device.

K0247

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups CAA and CAB, 3 Meter Distance, Modified Muff, July-Aug 1992)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, August 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups CAA and CAB, 3-m distance, condition C, of 14 volunteer subjects that arrived in June 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. The modified RACAL muff was used as a protective device.

K0248

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Group CBC, 3 Meter Distance, Modified Muff, Aug-Sep 1992)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, September 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Group CBC, 3-m distance, condition C, of 6 volunteer subjects that arrived by 10 August 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. The modified RACAL muff was used as a protective device.

K0249

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups CDF and CDG, 3 Meter Distance, Modified Muff, Nov-Dec 1992)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, December 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Group CDF and CDG, 3-m distance, condition C, of 12 volunteer subjects that arrived by 8 November 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. The modified RACAL muff was used as a protective device.

K0250

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups CEH and CEI, 3 Meter Distance, Modified Muff, Jan-Feb 1993)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, February 1993

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Group CEH and CEI, 3-m distance, condition C, of 9 volunteer subjects that arrived by the last week of December 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. The modified RACAL muff was used as a protective device.

K0251

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups CFJ and CFK, 3 Meter Distance, Modified Muff, Feb-Mar 1993)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, April 1993

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups CFJ and CFK, 3-m distance, condition C, of 14 volunteer subjects that arrived by February 1993. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. The modified RACAL muff was used as a protective device.

K0252

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups CGL and CGM, 3 Meter Distance, Modified Muff, Mar-Apr 1993)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, June 1993

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups CGL and CGM, 3-m distance, condition C, of 14 volunteer subjects that arrived by March 1993. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. The modified RACAL muff was used as a protective device.

K0253

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups CCD and CCE, 3 Meter Distance, Modified Muff, Sep-Oct 1992)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, Nov 1992

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects.

This interim report describes the results for Groups CCD and CCE, 3-m distance, condition C, of 10 volunteer subjects that arrived by September 1992. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. The modified RACAL muff was used as a protective device.

K0254

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups PAA and PAB, 3 Meter Distance, Perforated Ear Plug, May 1993)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, July 1993

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Groups PAA and PAB, 3-m distance, perforated ear plug, of 12 volunteer subjects that arrived by March 1993. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. This phase was a repeat of the 3-m distance study using a perforated ear plug.

K0255

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups PBC and PBD, 3 Meter Distance, Perforated Plug, Jul-Aug 1993)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, August 1993

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Groups PBC and PBD, 3-m distance, perforated ear plug, of 7 volunteer subjects that arrived by July 1993. The mortar simulator used was a steel tube that measured 22-inch-I.D., 26-inch-O.D., 2-inch-thick. The resulting peak SPL ranged from 173 dB (Level 1) to 193 dB (Level 7). The A-duration was approximately 1.5 msec. This phase was a repeat of the 3-m distance study using a perforated ear plug.

K0256

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Group BBB, 5 Meter Distance, Unmodified Muff, Sep-Oct 1989)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, October 1989

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Group BBB, 5-m distance, unmodified muff. The four volunteer subjects arrived by September 1989. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The RACAL muff was used as the hearing protector under test.

K0257

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Group BCC, 5 Meter Distance, Unmodified Muff, Oct-Nov 1989)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, November 1989

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Group BCC, 5-m distance, unmodified muff. The six volunteer subjects arrived by October 1989. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The RACAL muff was used as the hearing protector under test.

K0258

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups BDD and BDE, 5 Meter Distance, Unmodified Muff, Jan-Feb 1990)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, March 1990

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Group BDD and BDE, 5-m distance, unmodified muff. The 12 volunteer subjects arrived by January 1990. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The RACAL muff was used as the hearing protector under test.

K0259

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups BEF and BEG, 5 Meter Distance, Unmodified Muff, Mar-Apr 1990)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, April 1990

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Group BEF and BEG, 5-m distance, unmodified muff. The 12 volunteer subjects arrived by March 1990. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The RACAL muff was used as the hearing protector under test.

K0260

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups BFH and BFI, 5-Meter Distance, Unmodified Muff, Apr-May 1990)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, May 1990

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Group BFH and BFI, 5-m distance, unmodified muff. The 11 volunteer subjects arrived by May 1990. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The RACAL muff was used as the hearing protector under test.

K0261

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups BGJ-BGK, 5-Meter Distance, Unmodified Muff, Jun-Jul 1990)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, July 1990

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Group BGJ and BGK, 5-m distance, unmodified muff. The 13 volunteer subjects arrived by June 1990. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The RACAL muff was used as the hearing protector under test.

K0262

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups MAA-MAB, 5-Meter Distance, Modified Muff, Sep 1990)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, Oct 1990

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Groups MAA-MAB, 5-m distance, modified muff. The 10 volunteer subjects arrived by September 1990. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The modified RACAL muff was used as the hearing protector under test. The tests were accomplished under the amended protocol. The key feature of this amended protocol was the use of a muff with eight holes through the cushion to simulate a muff with a leaking seal similar to what could be expected in field use.

K0263

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups MBC-MBD, 5-Meter Distance, Modified Muff, Oct-Nov 1990)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, Nov 1990

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Groups MBC-MBD, 5-m distance, modified muff. The 12 volunteer subjects arrived by October 1990. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The modified RACAL muff was used as the hearing protector under test. The tests were accomplished under the amended protocol. The key feature of this amended protocol was the use of a muff with eight holes thorugh the cushion to simulate a muff with a leaking seal similar to what could be expected in field use.

K0264

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups MCE-MCF, 5-Meter Distance, Modified Muff, January 1991)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, Jan 1991

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Groups MCE-MCF, 5-m distance, modified muff. The 12 volunteer subjects arrived by January 1991. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The modified RACAL muff was used as the hearing protector under test. The tests were accomplished under the amended protocol. The key feature of this amended protocol was the use of a muff with eight holes through the cushion to simulate a muff with a leaking seal similar to what could be expected in field use.

K0265

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups MDG, 5-Meter Distance, Modified Muff, February 1991)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, March 1991

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Group MDG, 5-m distance, modified muff. The 6 volunteer subjects arrived by January 1991. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The modified RACAL muff was used as the hearing protector under test. The tests were accomplished under the amended protocol. The key feature of this amended protocol was the use of a muff with eight holes through the cushion to simulate a muff with a leaking seal similar to what could be expected in field use.

K0266

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups MFJ nd MFK, 5-Meter Distance, Modified Muff, May-June 1991)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, July 1991

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Groups MFJ and MFK, 5-m distance, modified muff. The 13 volunteer subjects arrived by May 1991. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The modified RACAL muff was used as the hearing protector under test. The tests were accomplished under the amended protocol. The key feature of this amended protocol was the use of a muff with eight holes through the cushion to simulate a muff with a leaking seal similar to what could be expected in field use.

K0267

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Direct Determination of Occupational Exposure Limits for Freefield Impulse Noise (Groups MEH-MEI, 5-Meter Distance, Modified Muff, Apri-May 1991)

SOURCE Interim Report, EG&G Special Projects, prepared for U.S. Medical Research and Materiel Command, Fort Detrick, MD, May 1991

ABSTRACT It was the objective of this study to determine the safe limits of occupational exposure while wearing hearing protection to impulse noise characteristic of mortars and howitzers fired in the open. Starting in October 1989, there were five major phases of testing accomplished using three study distances and four different types of hearing protection used by volunteer subjects: 1. 5-m distance, study conditions B and M; 2. 1-m distance, study condition D; 3. 3-m distance, study condition C; 4. 3-m distance, no-countdown study; and 5. 3-m distance, perforated ear plug, condition P.

This interim report describes the results for Groups MEH and MEI, 5-m distance, modified muff. The 10 volunteer subjects arrived by April 1991. Bare charges of C-4 explosive were used at a 5-m distance from the subjects. This resulted in peak sound pressure levels ranging from 173 dB at Level 1 to a maximum of 191 dB at Level 7. The A-duration was approximately 3 msec. The modified RACAL muff was used as the hearing protector under test. The tests were accomplished under the amended protocol. The key feature of this amended protocol was the use of a muff with eight holes through the cushion to simulate a muff with a leaking seal similar to what could be expected in field use.

K0268

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man, Task Order 3: Comparison of Blast Overpressure Effects on Two Versions of ACAPS

SOURCE Interim Report, EG&G Special Projects, Contract DAMD-17-88-C-8141, prepared for U.S.Army Medical Research and Development Command, Fort Detrick, MD, August 1991

ABSTRACT The development of a hearing protector for use by crew served artillery systems is currently in progress. Two designs for retaining the earcup to the head are being considered. During exposure to blast overpressure there is potential for movement of the hearing protector relative to the head.

The objective of this effort is to estimate which version moves least and remains closest to the starting position after undergoing exposure to a blast wave. During a 100-shot sequence of Task Order 1, there was an empty chair available in which a dummy could be placed. Thus, some testing of muff movement over a large number of shots could be accomplished. A dummy fitted with an ACAPS with the net-held suspension system was first placed on the dummy's head. The outline of the muff was traced so any movement could be analyzed. After shot 50, the muff with the band-held restraint was used.

K0269

AUTHOR Yelverton, J. T.

TITLE Blast Overpressure Studies with Animals and Man: Task Order 2 - Biological Response to Complex Blast Waves in a 17.3-m Enclosure

SOURCE Interim Task Order Report, FY90 Protocol, EG&G Special Projects, Contract DAMD-17-88-C-8141, U.S. Army Medical Research and Development Command, Fort Detrick, MD, March 1991

ABSTRACT A total of 129 sheep were exposed to C-4 charge detonations at various locations inside the variable-volume-all-steel enclosure. Five additional animals were used as experimental controls during the progress of the study. The volume was changed to 17.3 m3 (640 ft3) by placing a partition wall in the middle of the enclosure for this series of tests. There were 19 charge-target configurations utilized. For each exposure, two to three sheep at a time were suspended from the ceiling in cotton webbing harnesses at a height of 4.0 ft as measured from the floor to the xiphesternum. Depending upon the test requirement, a 114-, 227, 454-, or 907-g C-4 sphere was detonated at a height of 4.0 ft from the floor in the center, corner, or next to a wall of the enclosure. In one series of tests, two charges were detonated simultaneously near opposite walls of the chamber. Three exposures were done with two each 227-g charges and three with one 227-g and one 454-g charge each.

K0270

AUTHOR Johnson, D. R., Yelverton, J.T., Hicks, W. and Doyal, R.

TITLE Blast Overpressure Studies with Animals and Man: Task Order 4 - Nonauditory Damage Risk Assessment for Simulated Weapons Fired from an Enclosure

SOURCE Final Report, EG&G Special Projects, Contract DAMD17-88-C-8141, U.S. Army Medical Research and Development Command, Fort Detrick, MD, November1993

ABSTRACT Anesthetized sheep were exposed to a reverberant wave environment like that produced form firing an antitank weapon from a room. The simulation was accomplished by detonating C4 explosive outside a chamber of 18.2m3 volume. The blast wave traveled into the chamber through a 20 cm I.D. tube and was reflected off the back wall and subsequently through the chamber. The resulting waveform very closely approximated that generated by a Carl-Gustav anti-tank weapon fired from a chamber. A series of 1-shot, 3-sot, 2.5 min. apart; or 12-shot, 2.5 min. apart, exposures were used. The results indicate that multiple shots have a strong additive effect, deceasing the subthreshold levels. The subthreshold for a single blast is estimated to be below a smoothed peak of 31 kPa (approximately 65 kPa unsmoothed). The subthreshold for 3 exposures is estimated to be below 21.5 kPa (approximately 46 kPa unsmoothed). The subthreshold for 12 exposures was not found.

K0271

AUTHOR Yelverton, J. T., Johnson, D. L., Hicks, W., and Doyal, R.

TITLE Blast Overpressure Studies with Animal and Man: Task Order 2 - Biological Response to Complex Blast Waves

SOURCE Final Report, EG&G Special Projects, Contract DAMD-17-88-C-8141, U.S. Army Medical Research Acquisition Activity, SGRD-RMA-RC, Ft Detrick, MD, October 1993

ABSTRACT Anesthetized sheep were exposed to explosions generated by the detonation of various weights of C-4 ranging in size from 57 to 1361 g in three different enclosures. The dimensions of the enclosures were 3.05 x 1.52 x 2.44 m, 3.05 x 2.44 x 2.44 m, and 4.88 x 3.05 x 2.44 m or 11.3, 18.2, and 36.3 m3, respectively. The results from these experiments were used to establish an injury prediction curve using severity of injury indices and smoothed peak pressure. It appears to be an adequate model for the data collected and correlates well with previously reported injury prediction curves. It was determined that quasi-static pressure per se doesn't influence nonauditory injury to any appreciable degree. However, changes in the quasi-static pressure can affect the reverberant nature of the complex wave which seems to have a role in solid intra-abdominal response. There was a simple relationship between lung injury and loading density demonstrated. As loading density increases, lung injury increases.

K0272

AUTHOR Yelverton, J. T. and Johnson, D. L.

TITLE Blast Overpressure Studies with Animals and Man: Task Order 2 - Biological Response to Complex Blast Waves in Various Enclosure Volumes

SOURCE Interim Report, Task Order 2 FY 91 Protocol, EG&G Special Projects, Contract DAMD17-88-C-84-8141. U. S. Army Medical Research Acquisition Activity, SGRD-RMA-RCG, Fort Detrick, MD, December 1991

ABSTRACT A total of 142 sheep were exposed to C-4 charge detonations in a variable-volume-all-steel enclosure or outdoors in the freefield. Four additional animals were used as experimental controls during the progress of the study. The study was divided into three parts in which 16 charge-target configurations were utilized. For one part of the study, the enclosure dimensions were 16 x10 x 8 ft and for the second part a portion was placed inside the chamber to reduce its size to 10 x 5 x 8 ft. The last part of the study was conducted outdoors in the freefield to determine if the injuries sustained from blast tend to vary as a function of subject orientation with respect to the blast. The outdoor exposure results will also be compared wit the injuries sustained by the sheep at comparable ranges in the two different enclosure volumes.

K0273

AUTHOR Merickel, B.

TITLE Blast Overpressure Studies: Task Order 5 - Part II: Nonauditory Damage-Risk Assessment for Simulated Weapons Fired 100 Times from an Enclosure

SOURCE Final Report, EG&G Management Systems, Inc., Contract DAMD17-93-C-3101, U.S. Army Medical Research and Materiel Command, Ft Detrick, MD, October 1997

ABSTRACT Anesthetized sheep were exposed to a reverberant wave environment like that produced from firing an antitank weapon from a room. The simulation was accomplished by detonating C4 explosives outside a chamber of 18.2 m3 volume. The blast wave traveled into the chamber through a 20-cm I.D., tube and was reflected off the back wall and subsequently thoughout the chamber. The resulting waveform very closely approximated that generated by a Carl-Gustav antitank weapon fired from a chamber. Part I of the studies indicated that for a series of 1 sot or 3 shots, 2.5 minutes apart, multiple shots have a strong additive effect, decreasing the subthreshold levels. The subthreshold for a single blast was estimated to be above a peak of 48 kPa. The subthreshold for 3 exposures was estimated to be at 44 kPa. This study, called Part II, used 100 shots, 1 minute apart. For this exposure, a subthreshold peak of at least 23 kPa was verified using 19 animals.

K0274

AUTHOR Yelverton, J. T., Johnson, D. L., Hicks, W., and Merickel, B.

TITLE Blast Overpressure Studies: Task Order 2 - Nonauditory Damage Risk Assessment for Simulated Muzzle Blast from a 120mm M121 Mortar System

SOURCE Final Report, EG&G Management Systems, Inc., Contract DAMD1793-C-3101, U.S.Army Medical Research and Materiel Command, Fort Detrick, MD, October 1997

ABSTRACT This study was undertaken to establish the subthreshold, threshold, and suprathresholds for nonauditory injuries in a simulated muzzle blast environment like that produced when firing a 120mm M121 mortar system. A vertical axis explosively driven shock tube, in combination with reflector shields, was used to produce the required muzzle blast pressure-time pattern. Varying numbers of anesthetized sheep were subjected to 6 or 50 blasts of simulated muzzle blast waves in 1.5- to 3.0-dB increments. The results of the study demonstrated that sheep could be exposed to Pmax levels consisting of 6 blasts of 36 kPa each and 50 blasts of 30 kPa each and sustain no-injuries to trivial upper respiratory tract injuries at most. Threshold inquires were calculated to occur at 53 and 34 kPa for 6- and 50-blast exposures, respectively. Suprathresholds for URT and GI tract lesions were predicted to be 60 and 46 kPa for 6 and 50 blasts each. A suprathreshold for lung hemorrhage was predicted at 277 kPa for 6 exposures. Comparative analyses of this study with previous complex wave studies demonstrated that the safe nonauditory subthreshold for as many as 100 complex blast wave exposures was 22 kPa.

K0275

AUTHOR Yelverton, J. T.

TITLE Blast Overpressure Studies: Task Order 2 - Nonauditory Damage Risk Assessment for Simulated 155mm Self-Propelled Howitzer Muzzle Blast

SOURCE Final Task Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, February 1997

ABSTRACT This study was undertaken to establish the nonauditory injury subthreshold in a simulated muzzle blast environment like that produced when firing an M109 155 mm self-propelled howitzer (SPH) with one or more hatches open. An explosively driven shock tube, the hull of an M108 SPH, and a six-plate reflector system were used to produce the required muzzle blast signature. Using as many as 40 anesthetized sheep for each exposure condition, safe no-injury levels were established with an occasional minor upper respiratory tract lesion. Thee levels were 24 kPa for 6 blasts and 20 kPa for 25 to 100 blasts.

K0276

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 and 4 - Firing from an Enclosure Simulator

SOURCE Final Task Report, Task Orders 1 and 4, EG&G Management Systems, Inc., Contract DAMD17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD February 1997

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1.
Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug did appear to provide adequate protection up to the auditory limits for this waveform. This portion of the research was accomplished underTask Order 4.

K0277

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 101 and 102

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, July 1994

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished underTask Order 4.

This interim report describes the results of groups 101 and 102. Eight subjects arrived May 1994.

K0278

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 103 and 104

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, August 1994

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished underTask Order 4.

This interim report describes the results of groups 103 and 104, testing period was July-August 1994. Eight subjects arrived in July 1994.

K0279

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 105 and 106

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, September 1994

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished underTask Order 4.

This interim report describes the results of groups 105 and 106, testing period was September-October 1994. Seven subjects arrived in September 1994.

K0280

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 107 and 108

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, December 1994

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished underTask Order 4.

This interim report describes the results of groups 107 and 108, testing period was November 1994. Six subjects arrived in November 1994.

K0281

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 109, 110, and 111

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, February 1995

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished underTask Order 4.

This interim report describes the results of groups 109, 110, and 111, testing period was January 1995. Thirteen subjects arrived in January 1995.

K0282

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 112, 113, and 114

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, March 1995

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished underTask Order 4.

This interim report describes the results of groups 112, 113, and 114, testing period was February-March 1995. Eleven subjects arrived in February 1995.

K0283

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 115, 116, and 117

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, May 1995

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished under Task Order 4.

This interim report describes the results of groups 115, 116, and 117. Ten subjects arrived in March 1995. Testing period was March-April 1995.

K0284

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 1 - Firing from an Enclosure Simulator, Groups 118, 119, and 120

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, June 1995

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished under Task Order 4.

This interim report describes the results of groups 115, 116, and 117. Eleven subjects arrived in June 1995. Testing period was April-May 1995.

K0285

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 4 - Nonlinear Earplug Study, Groups 201, 202, 203, and 204

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, October 1995

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished under Task Order 4.

This interim report describes the results of groups 201, 202, 203, and 204. Thirteen subjects arrived in July 1995. Testing period was August-September 1995. The nonlinear plug study started with the arrival of 13 subjects staggered over a 2-week period beginning 22 July. All thirteen subjects were accepted and the exposures of the first group of subjects were started on 7 August. The last group of subjects were started 16 August. In addition to the auditory baselines, occluded baselines were obtained for the EAR foam plug in the left ear and nonlinear plug in the right ear. It quickly became evident that the nonlinear plug was not protecting as well as expected.

K0286

AUTHOR Johnson, D. L.

TITLE Blast Overpressure Studies: Direct Determination Exposure Limits for Intensive Reverberant Impulse Noise, Task Order 4 - Nonlinear Earplug Study, Groups 205, 206, 207, and 208

SOURCE Interim Report, EG&G Management Systems, Inc., Contract DAMD-17-93-C-3101, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD, November 1995

ABSTRACT To satisfy the Army's need for realistic safe limits for heavy weapon noise while wearing hearing protection, a 2-1/2-year study was undertaken. Using active duty military volunteers, 64 subjects established that the auditory system could be adequately protected with the RACAL muff from one to three exposures of the reverberant waveforms obtained from a rocket launcher out of an enclosure. Thus, nonauditory considerations set the exposure limits for this type of waveform. This research was accomplished under Task Order 1. Using 27 subjects, two types of nonlinear (increasing attenuation with level) plugs type of hearing protection were evaluated using 6 to 100 exposures of a freefield waveform of 1.5-ms duration. With the limited number of subjects, neither plug was proven adequate to protect the auditory system from this type of waveform. Several subjects had a temporary threshold shift (TTS) of their hearing of more than 25 dB. The compressible foam plug, did appear to provide adequate protection up to the auditory limits for this waveform. This research was accomplished under Task Order 4.

This interim report describes the results of groups 205, 206, 207, and 208. The second part of the nonlinear plug study started with the arrival of 14 subjects 2-4 September 1995. Because testing of the previous groups of subjects was not completed until 12 September, about a 1-week delay occurred before they could start audiometric baselines. Additionally, because of the relatively poor performance of the nonlinear plug used with the previous groups of subjects, a different plug configuration was approved. The configuration approved was the same ultrafast plug, but with a filter in the front end, designed at the French-German Research Institute Saint-Louis (ISL), Saint Louis, France. This nonlinear plug was called the "French No. 1" plug. The No. 1 designation comes from the fact that they called this special Filter No. 1, distinguishing it from a similar filter they called No. 2. The ISL provided fifteen of these filters.

K0287

AUTHOR Richmond, D. R.

TITLE The Biological Effects Produced by Experimental FAX Charges

SOURCE Technical Progress Report, Lovelace Foundation for Med. Ed. And Res., Contract DA-49-146-XZ-055, Defense Atomic Support Agency, Washington, DC, June 1965

ABSTRACT The biological effects of experimental FAX charges containing 10, 30, and 80 lb of ethylene oxide were assessed using 348 goats, sheep, and cattle. Animals were exposed on the surface and in foxholes and bunkers located within and beyond the fuel-air cloud. Pressure-time measurements were taken with piezoelectric gauges. Lethality, nature of injuries, and incapacitation obtained were discussed with reference to estimating the effectiveness of the FAX system against personnel.

K0288

AUTHOR Richmond, D. R.

TITLE FAE Effects on Personnel in General

SOURCE Foreign Travel Trip Report, Los Alamos National Laboratory, presented at the meeting of the NATO AD HOC Working Group of Protective Construction Measures, Oslo, Norway, May-June 1988

ABSTRACT The report gave the blast and thermal effects on dummies inside a Norwegian field fortification, Valhall II, exposed to three FAE weighing 43 kg, 3000 kg, and 1000 kg. On the 1000-kg shot, dummies were placed in the open. The tests were conducted at White Sands Missile Range in July 1987.

K0289

AUTHOR Richmond, D. R. and Pratt, D. E.

TITLE The Effectiveness of 80-lb FAX Charges Against Primates in the Open, in Foxholes, and in Bunkers

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, submitted to Commander (Code 4563), US Naval Ordnance Test Station, China Lake, CA (formerly Confidential, declassified 4/82), 1967

ABSTRACT A follow-up study was carried out on the effectiveness of 80-lb fuel-air explosive (FAX) devices against primates. Ten tests were conducted at a foxhole-bunker site with the charge located (1) to the rear of the bunker, (2) 40 to 45 ft from in front of the bunker, (3) at ranges beyond 30 ft from the shallow foxholes, or (4) at 25- and 30-ft ranges from the deep foxhole. Seven monkeys (Macaca mulatta) were used per test and were placed in either the structures or at 40- to 70-ft distances in the open. Particular emphasis was given to eye injuries. The eyes of the monkeys were examined by an ophthalmologist with a slit lamp immediately post-shot and photographed. Eyes were again assessed in the laboratory in the preserved condition. Animals were autopsied and gross pathological findings recorded. Pressure-times were measured in the bunker, deep foxhole, and at three locations in the open. Range-effects relationships for animals in the structures and in the open were compiled and discussed.

K0290

AUTHOR Jennsen, A.

TITLE Vulnerability of Protective Structures Subjected to Fuel-Air-Explosive Weapon Attack

SOURCE Final Report, Special Study Group of Experts, prepared for the Norwegian Defense Construction Service, Oslo, Norway, June 1988

ABSTRACT At the request of the Norwegian Defence Construction Service, a team of experts visited selected protective facilities in Norway in June 1988 to assess their vulnerability to attack by fuel-air explosives (FAE) weapons. The wide range of facilities visited included petroleum, oil, and lubricant (POL) facilities, aircraft shelters, and hardened command and control installations. This report summarizes the findings and proposes measures that can be taken to reduce the vulnerability of these facilities. Recommendations are also made for further studies to better quantify the vulnerabilities and to evaluate proposed mitigating measures.

K0291

AUTHOR Richmond, D. R.

TITLE The Effects of Fuel-Air Explosions on Dummies Inside the Valhall II and in the Open

SOURCE Final Report, Life Sciences Division, Los Alamos National Laboratory, prepared for Norwegian Defence Construction Service, Oslo, Norway, April 1988

ABSTRACT Introduction: Anthorpomorphic dummies were used to evaluate the environment inside the Valhall II field fortification subjected to fuel-air explosion. Dummies were located inside the fortification three tests: Phases I-3, I-4, and I-5. On one of the tests, Phase I-5, dummies were placed in the open and in a truck at ranges behind the periphery of the fuel-air cloud. Direct blast (overpressure), blast displacements, and thermal effects were evaluated.

K0292

AUTHOR Richmond, D. R.

TITLE FAE Effects

SOURCE Technical Paper, Los Alamos National Laboratory, presented at Meetings at Establissement Technique de Bourges, NATO Panel VIII, RSG-6 Group, Effects of Impulse Noise, Bourges, France, June 1987

ABSTRACT Objectives: The objectives of this presentation are to: (1) Describe the damage mechanisms associated with FAE. (2) Present the criteria that were developed to estimate the probability of human lethality, i.e., percent incidence combat ineffectiveness (CI) from the various damage mechanisms. 3. Provide curves that relate the percent CI as a function of distance from the different weights of fuel. 4. Give the results of specific tests that demonstrate the effectiveness of FAE.

K0293

AUTHOR Fletcher, E. R., Bowen, I. G., Jones, R. K., and Richmond, D.

TITLE Airblast Effects on Personnel

SOURCE Letter of transmittal w/enclosures, Lovelace Foundation for Medical Education and Research, prepared for U.S. Army Combat Development Command, Institute of Nuclear Studies, Fort Bliss, TX, January 1969.

ABSTRACT Response to letter re: CDINS-E of November 13, 1968.

K0294

AUTHOR Richmond, D. R.

TITLE Necropsy Results, Underwater Blast Study

SOURCE Letter of transmittal, Lovelace Foundation for Medical Education and Research, prepared for Explosives Technology, Farfield, CA, October 1976

ABSTRACT Letter enclosing necropsy results. "No detectable internal effects from the underwater blast. All animals appeared uninjured from external signs."

K0295

AUTHOR Richmond, D. R.

TITLE Underwater Explosion Levels Evaluated by a Swimmer

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, presented at 2nd Conference on the Environmental Effects of Explosions and Explosions, Naval Surface Weapons Center, Silver Spring, MD, October 1976

ABSTRACT This study was to determine the underwater-blast levels that would be comfortable to an unprotected swimmer. Twenty-two tests were conducted in a 220- x 150-ft underwater-test facility (30 ft deep) with explosive charges up to 2.6 lb. Six tests were run in open water (25 and 150 ft deep) with charges up to 190 lb. (?) On most of the tests the underwater-blast waveforms were measured by gauges located at 1-ft depths adjacent to the swimmer. The peak pressures, impulses (time-integral of pressure), and cut-off times were calculated from the gauge records and presented with the sensations described by the swimmer. Impulses of 1.0 psi.msec or more were evaluated by the swimmer with his head above the surface for (a) peak pressures of 50 to 118 psi from charges fired at or deeper than a 10-ft depth of bursts (DOB), (b) peak pressures of 139-216 psi from charges fired at a 1-ft DOB, (c.) swimmer near a reflecting surface, and (d) swimmer in a wet suit. The noise from underwater explosions was also assessed while the subject's ears were at 1-ft depths, head facing the charges. The sounds from the following underwater blasts were tolerable and did not produce tinnitus: impulses of 0.25 psi.msec to 1.31 psi.msec with respective peak pressures of 12 psi to 52 psi (blasting caps, 10-ft DOB); and impulses of 1.0 to 2.0 psi.msec with peak pressures of from 48 psi to 71 psi (0.5-lb charges, 10-ft DOB). Some information on the bottom reflected waves, having atypical waveforms, encountered was included. A 1 psi.msec criterion as an acceptable underwater-blast level for swimmers was discussed.

K0296 NSWC/WOL/TR 77-36

AUTHOR Yelverton, J.T. and Richmond, D. R.

TITLE The Relationship Between Fish Size and Their Response to Underwater Blast

SOURCE Technical Paper, Lovelace Foundation for Medical Education and Research, presented at 2nd Conference on the Environmental Effects of Explosions and Explosions, Naval Surface Weapons Center, Silver Spring, MD, October 1976

ABSTRACT Fish were exposed to underwater blasts in an artificial pond, 220 x 150 ft, that was 30 ft deep. The underwater-blast impulse levels required for 50-percent mortality, 1-percent mortality, and no-injuries were determined for eight species of fish. There was good correlation between the LD50 impulse and the body weight of the fish. These ranged from 1.7 psi.msec for 002-g guppy fry to 49.5 psi.msec for 744-g carp. No difference was detectable in the underwater blast response of fish that had ducted swimbladders and those that had nonducted swimbladders. Application of the results of this study to predicting the response of fish to underwater explosions was discussed.

K0297

AUTHOR Richmond, D. R. and Axelsson, H.

TITLE Airblast and Underwater Blast Studies with Animals

SOURCE Technical Paper, EG&G Mason Research Institute, presented at the 6th International Symposium on Wound Ballistics, Chongquing, China, 1-4 November 1988

ABSTRACT Introduction: Airblast injury mechanisms may be divided into the direct and indirect effects. The direct effects result from the impact of the blast wave on the body. Indirect effects are associated with the flow in the blast wave or blast wind translating individuals into objects, causing building collapse, and hurling debris. The indirect effects will not be discussed in this paper. There is a definite syndrome from direct blast effects in that the gas containing organs of the body are disrupted and become hemorrhaged These are the ears, lungs, lining of the upper respiratory tract (including the sinuses), and the gastrointestinal tract. The severity of these injuries grows with the intensity of the blast. When the blast overpressures are in the lethal range, air enters the circulation from the disrupted lung tissues. The sort survival time is a consequence of these air bubbles (emboli) in the heart and brain. The only external signs observed in blast victims are bloody froth at the nose and mouth, a labored respiration (air hunger) and signs of disruption of the central nervous system.
Biological response depends a great deal on the shape of the blast wave. Most of our work involved ideal or Freidlander-type wave--the kind of waves generated from detonating explosive charges in the open. These waves are characterized by an initial shock front with a peak overpressure occurring almost instantaneously followed by a rapid exponential drop to ambient pressure and a subsequent negative phase. The biologic response to Friedlander waves is related to the peak overpressure and the duration of the overpressure.

K0298

AUTHOR Yelverton, J. T., Richmond, D. R., Fletcher, E.R., and Jones, R. K.

TITLE Safe Distances from Underwater Explosions for Mammals and Birds

SOURCE Final Report, Lovelace Foundation for Medical Education and Research, prepared for Naval Ordnance Laboratory, Silver Spring, MD, April 1973

ABSTRACT Tests were run to determine the far-field underwater blast effects on mammals and birds. The tests were conducted in a specially constructed test pond facility, 220 x 150 ft at the surface and 30 ft deep over the 30- x 100-ft center portion. Explosive charges weighing up to 8 lb were detonated at 10-ft depths.
Sheep, dogs, and monkeys were suspended in the water mostly with their long axis perpendicular to the surface at 1-, 2-, and 10-ft depths. The duck was selected as a model to represent birds on the surface and birds that dive beneath the surface. They were tested on the water surface and at 2-ft depths.
The nature of the immersion-blast injuries was described and related to the impulse measured in the underwater blast wave. Impulse levels that were safe and that produce injuries in mammals and birds were presented.
Underwater-blast criteria were presented that corresponded to safe and damaging impulse levels for birds and mammals along with curves relating the impulse criteria as a function of range and charge weight.

K0299

AUTHOR Fletcher. E. R.

TITLE The Physics of Decelerative Tumbling, Operation Plumbbob

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, July 1965

ABSTRACT Experiments on Operation Plumbbob were described in which total distances of displacement were measured for stones and building blocks translated by blast winds. In subsequent experiments the mechanisms of decelerative tumbling were investigated for blocks, stones, and animals to help interpret the results of the field tests. A mathematical model was briefly described which was designed to simulate the decelerative-tumbling motion of an object moving over a flat surface. Comparisons were made between the output of the model and experimental results for blocks. The experimental results for animals were compared to those of Anderson et al. for goats and dummies which were ejected over flat ground from the open end of a shock tube. Possible approaches to future investigations were mentioned.
This report is a documentation of a speech presented at the Fifth Meeting of Panel N-1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, May 11, 1965, at the U.S. Naval Radiological Defense Laboratory, San Francisoco, CA.

K0300

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1963-1964

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1963-1964.

K0301

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1964-1965

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1964-1965

K0302

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1965-1966

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1965-1966

K0303

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1966-1967

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1966-1967

K0304

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1967-1968

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1967-1968

K0305

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1968-1969

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1968-1969

K0306

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1969-1970

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1969-1970

K0307

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1970-1971

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1970-1971.

K0308

AUTHOR White, C. S.

TITLE Annual Report, Lovelace Foundation for Medical Education and Research

SOURCE Lovelace Foundation for Medical Education and Research, 1971-1972

ABSTRACT Describes total research effort for the Lovelace Foundation for FY 1971-1972..

K0309 DNA 3151P1

AUTHOR Fletcher, E. R., Richmond, D. R., Jones, R. K., Jackson, W. S.

TITLE Blast Effects on Helicopter Plexiglas Windows, Program 1 - Airblast, Project LN 115/402

SOURCE Preliminary Report, Lovelace Foundation for Medical Education and Research, in Proceedings of the Mixed Company/Middle Gust Results Meeting, 13-15 Mar 1973, Defense Nuclear Agency, Washington, DC, May 1973

ABSTRACT Objectives: 1. To determine the velocity, mass, shape, and spatial distributions of the plexiglas fragments inside UH-1 helicopters. 2. To use motion-picture cameras to view the break-up of windows in the helicopters. 3. To use shock-tube mock-ups to expose flat panes of plexiglas to blast and to compare the results with those obtained in the helicopters. 4. To estimate the nature and severity of biological damage that might results from the impact of such plexiglas fragments on aircrews and passengers.

K0310 DASA 2228-I

AUTHOR Richmond, D. R., and Jones, R. K.

TITLE Effects of Airblast on Sheep in Two-Man Foxholes, Operation Prairie Flat, Project LN 401

SOURCE Final Project Officers Report, Lovelace Foundation for Medical Education and Research, in Operation Prairie Flat Preliminary Report, Vol. I, pp 634-644, January 1969

ABSTRACT The objective of this project was to determine the air-blast protection that two-manfoxholes afforded a large biological specimen (sheep).

K0311 DASA-2606-1

AUTHOR Richmond, D. R. and Fletcher, E. R.

TITLE Blast Displacement of Dummies on the Surface, Project LN401, Event Dial Pack

SOURCE Final Report, Project Officers, Lovelace Foundation for Medical Education and Research, Event Dial Pack Preliminary Report, Vol. I-Part II, Defense Atomic Support Agency Information and Analysis Center, Santa Barbara, CA May 1971

ABSTRACT Objective: The purpose of this experiment was to determine the distances that dummies on the surface were displaced by the air blast from the Dial Pack 500-ton explosion. These distances will be used as a basis for verifying, or for modifying, an existing mathematical model for the displacement of personnel.

K0312 DNA 4377P-2

AUTHOR Richmond, D. R., Yelverton, J. T., Fletcher, E. R., Hicks, W., Saunders, K., and Trujillo, A.

TITLE Blast Effects on the Crews of U.S. Army Tactical Equipment, Dice Throw Event

SOURCE Project Officers Report, Lovelace Biomedical and Environmental Research Institute, in Proceedings of the Dice Throw Symposium, Vol. 2, Section 11, 132 pp, Defense Nuclear Agency, Washington, DC, June 1977

ABSTRACT [need abstract-check document]

K0313 DNA 4377P-2

AUTHOR Fletcher, E. R., Richmond, D. R., Clark, R. O. and Yelverton, J.T.

TITLE Blast Displacement in Field Fortifications, Event Dice Throw

SOURCE Project Officers Report, Lovelace Biomedical and Environmental Research Institute, in Proceedings of the Dice Throw Symposium, Vol. 3, Section 11, 36 pp, Defense Nuclear Agency, Washington, DC, June 1977

ABSTRACT [need abstract-check document]

K0314 DNA 3151P1

AUTHOR Richmond, D. R, Fletcher, E.R., Jones, R. K. and Jackson, W. S.

TITLE Airblast Effects Inside Field Fortifications, Program 4-Biomedical, Project LN 401, Mixed Company/Middle Gust Event

SOURCE Preliminary Project Officers Results Report, Lovelace Foundation for Medical Education and Research, in Proceedings of Mixed/Company Middle Gust Results Meeting, March 1973, DASIAC, Santa Barbara, CA, May 1973

ABSTRACT Objectives: To study the airblast displacement of dummies inside an open underground personnel shelter. 2. To evaluate airblast displacement hazards inside two fighting bunkers through the use of dummies.

K0315 DNA 3151P1

AUTHOR Richmond, D. R. and Jackson, W. S.

TITLE Airblast Effects In Foxholes, Program 4-Biomedical, Project LN 403, Mixed Company/Middle Gust Event

SOURCE Project Officers Results Report, Lovelace Foundation for Medical Education and Research, in Proceedings of Mixed/Compan Middle Gust Results Meeting, March 1973, DASIAC, Santa Barbara, CA, May 1973

ABSTRACT Objectives: To obtain some information on blast displacement effects using dummies in an open and two-thirds covered foxhole located in the near field and (2) to obtain pressure-time recordings inside and outside an open foxhole located in the far field.

K0316

AUTHOR Richmond, D.R. and Damon, E. G.

TITLE Primary Blast Injuries in the Open and in Foxholes Resulting from Nuclear Type Detonations

SOURCE Technical Report, Technico Southwest, Inc., Contract DNA-001-88-C-0207, prepared for Defense Nuclear Agency, Washington, DC, September 1990

ABSTRACT The nature of primary blast injuries that affect the gas-containing organs in the body are described and illustrated in this report. A history of blast-injury research that includes descriptions of the proposed damage mechanisms, cause of death and clinical manifestations is also presented. Estimates of the incident blast levels required to produce lung and GI tract injuries in man are based on the results of tests with animals. There are three blast exposure scenarios 1. For personnel prone, end-on to the blast in the open, 2. For personnel in open, two-man foxholes, with the blast wave rising in multiple steps. 3. For personnel in the foxhole, with the blast wave rising in a single step.

K0317 POR 7158-4

AUTHOR Yelverton, J. T. and Fletcher, E. R.

TITLE Dummy Response, Minor Scale Event, Valhall II, Experiment 7410

SOURCE Project Officers Report, Los Alamos National Laboratory, in Proceedings of the Minor Scale Symposium, February 1986, Vol. IV, pp 85-102, Field Command, Defense Nuclear Agency, Washington, DC, June 1986

ABSTRACT [check document for abstract]

K0318

AUTHOR Richmond, D. R, Fletcher, E. R., and Jones, R. K.

TITLE Blast Protection Afforded by Foxholes and Bunkers, Event Dial Pack, Project LN401

SOURCE Project Officers Report, Lovelace Foundation for Medical Education and Research, in Proceedings, Event Dial Pack Symposium, published by the Defence Research Board of Canada, Vol.II, pp 581-606, March 1971

ABSTRACT [check document for abstract]

K0319

AUTHOR Fletcher, E. R., Richmond, D.R., and Jones, R. K.

TITLE Blast Displacement of Dummies in Open Terrain and in Field Fortifications, Event Dial Pack, Project LN402

SOURCE Project Officers Report, Lovelace Foundation for Medical Education and Research, in Proceedings, Event Dial Pack Symposium, published by the Defence Research Board of Canada, Vol.II, pp 607-625, March 1971

ABSTRACT [check document for abstract]

K0320

AUTHOR Richmond, D.R.

TITLE Tables: Underwater Gut Rupture vs Bubble Size

SOURCE Personal papers, Lovelace Foundation for Medical Education and Research, tabulated data, prepared for Naval Ordnance Laboratory, Silver Spring, MD, 1973

ABSTRACT [none available]

K0321

AUTHOR Richmond, D. R., Yelverton, J.T., Hicks, W., and Phillips, Y.Y.

TITLE Biological Effects of Complex Blast Waves from Explosions Inside an Enclosure

SOURCE Draft Results Report, Los Alamos National Laboratory, prepared for Walter Reed Army Institute of Research, Washington, DC, February 1987

ABSTRACT Introduction: The purpose of this paper is to report the results of experiments to evaluate the effects of complex blast waves in sheep. The complex waves were generated by detonating bare explosive charges inside an M59 Armored Personnel Carrier (APC). The objectives of this study were (1) to evaluate the airblast injuries from 113-, 227-, and 454-g explosions, primarily inside the passenger compartment of the APC; (2) assess the influence of Kevlar vests on the experimental subjects; (3) measure pressure time inside the thorax of sheep and a Swedish dummy in a complex blast environment; and (4) attempt to determine the damage parameters of the complex blast waves.

K0322

AUTHOR Richmond, D. R. and Yelverton, J. T.

TITLE Blast Effects on Dummies in BRL FET-Event Minor Scale

SOURCE Project Officer's Results Report, Los Alamos National Laboratory, to be included as an appendix in the final U.S. Army Ballistic Research Laboratories Project Officers Report, Aberdeen, MD, July 1986 (draft copy)

ABSTRACT Forty dummies were used to assess the blast displacement effects on crew members and infantrymen in eight armor and four truck vehicles. The dummies were clothed in three different ways to represent armor crews, infantrymen in armored vehicles, and infantrymen in trucks. Significant damage to a dummy's foam plastic, representing the skin and musculature, was counted as a severe injury.

K0323

AUTHOR Clark, R. O.

TITLE Blast Effects on Dummies in Fighting Bunkers, Dice Throw Event

SOURCE Preliminary Results Report, Lovelace Biomedical and Environmental Research Institute, prepared for Field Command, Defense Nuclear Agency, Kirtland Air Force Base, NM, November 1976

ABSTRACT Objective: The objective of this project was to measure the motion of dummies exposed to the airblast induced flow into open fighting bunkers. The motion of the dummies would be monitored with high-speed photography. Other instrumentation included stagnation and static pressure gages to measure properties of the entering jet flow. Also, a specific acceleration indicator called an Impact-O-Graph was mounted in the chest cavity of the dummies. These devices were set to release at or beyond a specific acceleration.

K0324

AUTHOR Richmond, D. R.

TITLE On Fuel-Air Explosions

SOURCE Technical Presentation, Los Alamos National Laboratory, presented at the Meeting of Munitions Experts, Washington, DC, September 1985

ABSTRACT [not available]

K0325

AUTHOR Richmond, D. R.

TITLE Bioeffects from Bare Charges Detonated Inside Armored Vehicles

SOURCE Presentation vu-graphs, Los Alamos National Laboratory, Los Alamos, NM, 1985

ABSTRACT

K0326

AUTHOR Fletcher, E. R., Richmond, D. R., Jones, R. K., and Jackson, W. S.

TITLE Blast Effects on Helicopter Plexiglas Windows, Project LN115/402, Event Mixed Company Middle North Series

SOURCE Final Project Officer's Report, Lovelace Foundation for Medical Education and Research, Contract DAAD-05-72-C-0362, to Ballistic Research Laboratories, Aberdeen, MD, 1 December 1973

ABSTRACT Styrofoam witness plates and cameras were used to obtain information about the flying plexiglas fragments inside ten UH-2 helicopters in the vicinity of a 500-ton TNT detonation. The aircraft were oriented side-on and head-on in open terrain and side-on in revetments at ranges where the peak incident overpressures were 1.2, 2.3, 3.5, 5.0, and 8.8 psi. Twelve flat panes of plexiglas mounted on cubical wooden boxes were exposed head-on to similar overpressures. Masses, velocities, and spatial densities of the fragments were detailed for the boxes and for the crew and cargo sections of the helicopters. Approximations to the mass-velocity distributions were derived using egression analyses.

K0327

AUTHOR Young, A. J., Phillips, Y. Y., Jaeger, J. J.. Yelverton, J. T., and Richmond, D. R.

TITLE The Influence of Airway Pressure on Lung Injury Resulting from Airblast

SOURCE Military Medicine 150(1): 31-33, 1984

ABSTRACT Exposure to airblast can result in injury to the gas containing organs, most notably the ears, upper respiratory tract, lungs, and gastrointestinal tract. It has been reported that there was no correlation found between the respiratory phase during airblast and the degree of lung injury, but the size of the blast used in that study was so large that few animals could survive, and lung injury was probably so extensive that effects of respiratory phase may not have been apparent. The purpose of the present study as to determine what influence, if any, systematically varying the airway pressure (thus lung volume) would have on lung injury due to airblast. These results indicate that the airway pressure, and therefore, presumably lung volume, had no effect on lung injury resulting from airblast.

K0328

AUTHOR Grant, G., Yelverton, J. T., Matthes, A., Hicks, W., and Richmond, D.

TITLE Blast Effects on the Canadian XC4 Mask

SOURCE Final Project Officer's Report, Los Alamos National Laboratory, prepared for Defence Research Establishment, Ottawa, Canada, November 1986 (cy of rough draft)

ABSTRACT Foreword: The blast response of the Canadian XC4 mask was tested in an explosive-driven shocktube. Fourteen tests were conducted and the blast effects on 126 masks were evaluated. This report was prepared to provide the pressure-time measurements, shocktube characteristics, along with information on the response of the masks for inclusion in the Defence Research Establishment-Ottawa final report.

K0329

AUTHOR Fletcher, E. R., Yelverton, J. T., and Richmond, D. R.

TITLE Personnel Protection from Blast Displacement, Miser's Bluff Event

SOURCE Preliminary Data Report, Lovelace Biomedical and Environmental Research Institute, prepared for Defense Nuclear Agency, Washington, DC, 9 August 1978

ABSTRACT Introduction: The objectives of this project were (a) to determine the time-displacement history of anthropomorphic dummies located inside a 91.4 x 183 cm (3 x 6 ft) fighting bunker oriented side-on to the blast; (b) to determine the protection against blast displacement of personnel afforded by slight trenches of various depths, and (c) to determine the blast-displacement distances of anthropomorphic dummies at different orientations in the open.

K0330

AUTHOR Jones, R. K., Richmond, D. R., and Fletcher, E. R.

TITLE A Reapraisal of Man's Tolerance to Indirect (Tertiary) Blast Injuries

SOURCE Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, in Proc. Panel N5, Technical Cooperation Program Working Group on Therapy Regimes Meeting, London, April 1969

ABSTRACT

K0331

AUTHOR Fletcher, E. R. and Richmond, D. R.

TITLE Characteristics and Biological Effects of Fragments from Glass and Acrylic Windows Broken by Airblast

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, in Research Report 22, DCPA All-Effects Research Contractors Meeting, Pacific Grove, CA, April 21-25, 1974, October 1974

ABSTRACT Introduction: One of the major hazards from large conventional and nuclear explosions is from debris set in motion by blast winds and pressures. Evidence is cited in Reference 1 indicating that the most far-reaching hazard to occupants of houses and buildings is likely to be from window glass fragments. This paper contains an analysis of tabulated data concerning the physical characteristics of glass fragments from windows broken by airblast. Most of these data were obtained from experiments in which Styrofoam witness plates (3 o 17 ft from the windows) were used to trap the fragments such that their velocities, masses, and spatial distributions could be measured. Several sources of information on the biological effects of glass fragments are mentioned in Reference 1. Hazards criteria were developed in one study in which individual glass fragments were impacted against biological targets (Reference 2). Additional experiments have been conducted in which fragments were trapped 3 to 4 ft from stretched-acrylic, nonstretched-acrylic, and laminated-glass windows broken by airblast (References 3 and 4). The acrylic fragments generated in these experiments were subsequently impacted against biological targets in order to establish hazards criteria (Reference 5).
The purpose of this paper is to summarize some of the more important results from the above studies. These results will be presented in such a way s to facilitate comparisons among the data for the various window materials.

K0332

AUTHOR Richmond, D. R.

TITLE Results of Exploratory Tests for Planning Complex Blast Wave Effects Studies

SOURCE Report, EG&G Management Systems, Inc., to Walter Reed Army Institute of Research, Washington, DC, July 1983

ABSTRACT Introduction: This report gives the results of preliminary tests conducted to select methods for measuring pressure time, mounting animals, and type of explosives to be used in studies dealing with complex blast waves. The first one of the studies will measure pressure time in the thorax (ITP) of sheep exposed to complex blast waves generated by the detonation of small charges inside enclosures having different volumes. The data obtained will be compared with the ITP calculated by a mathematical model that was developed using ideal blast waves as input pattern. The ITP patterns will be analyzed in an attempt to correlate the components of the complex waves associated with lung injury. Particular attention will be given to detecting any resonance effects from the complex waves.

K0333

AUTHOR Richmond, D. R., Fletcher, E. R., and Yelverton, J. T.

TITLE Blast Effects on Anthropomorphic Dummies Inside a Norwegian Field Fortifications, Event Direct Course

SOURCE Final Report, Lovelace Biomedical and Environmental Research Institute, prepared for Norwegian Defense Construction Service, Oslo mil/Akershus, N-Oslo, Norway, March 1984

ABSTRACT Four anthropomorphic dummies were used to evaluate the blast environment inside a Norwegian field fortification on Event Direct Course. The structure was at a ground range of 295 ft where the anticipated incident overpressure level was 150 psi. The charge was 618 tons of ammonium nitrate-fuel oil mixture on a tower at 166 ft above the surface. The structure consisted of four weapons emplacements connected by an underground tunnel. Dummies were placed standing in the recoilless rifle bunker, the heavy machine gun bunker, the light machine gun bunker, and in the connecting tunnel. The dummies contained peak-g reading accelerometers in their head and chest cavities and were viewed with high-speed cameras.
The field fortification was heavily damaged except for the light machine gun bunker. All the dummies were extensively damaged. The heads and arms were stripped from two of the subjects and large areas of foam plastic was removed from their skeletal structure. Damage to the subjects was caused by fragmentation of the structure, whole-body displacement with subsequent impact, and high-velocity jet flow acting on the subjects.
The high-speed motion-pictures did not provide any information on the blast displacement velocities of the dummies because of malfunction and dust obscuration.
The overpressure levels measured at the dummy locations would be in the lethal range for the direct overpressure effects estimated for man.

K0334

AUTHOR Richmond, D.R., Fletcher, E. R., and Yelverton, J. T.

TITLE Blast Effects on Anthropomorphic Dummies Inside the French AMF-80 Shelter, Event Direct Course, Experiment 6200 France/BRL

SOURCE Final Report, Lovelace Biomedical and Environmental Research Institute, prepared for Defense Nuclear Agency, Kirtland Air Force Base, NM, March 1984

ABSTRACT On the Direct Course Event, four anthropomorphic dummies were placed inside the French AMF-80 personnel shelter to evaluate blast-displacement effects on personnel. The shelter was at the anticipated 3 bar overpressure level. The long axis of the shelter was oriented perpendicular to the radial line to the charge. One dummy was laying supine in a litter and one was seated on a bench beneath the litter both on the upstream and downstream sides of the structures. According to the motion-picture camera records, the initial shelter motion was downward and away from the blast source. All the subjects remained in their initial orientations although the dummy in the litter on the upstream wall was almost hurled from the litter.
The maximum horizontal velocity and displacement of the dummies were 3.9 ft/sec and 8.6 in., respectively. The maximum vertical velocity and displacement were 2.3 ft/sec and 1.6 in., respectively.
The results were compared with those obtained from tests wherein an AMF-80 shelter containing dummies was subjected to blasts from buried 500- and 1000-lb bombs.

K0335

AUTHOR Richmond, D. R., Yelverton, J.T., Berkbigler, L. W., Moore, L. M., and Phillips, T. T.

TITLE Blast Effects Behind Armor

SOURCE Technical Paper, LA-CP-88-12, Los Alamos National Laboratory, Los Alamos, NM, 1988

ABSTRACT Introduction: When a shaped-charge penetrates through the armor of a vehicle, the entering jet produces a spall cone of high-velocity fragments, blast overpressure, a rise in temperature light flash, and smoke. The jet may also strike components inside the vehicle and initiate fires and explosions.
In the past, fragment wounds and burns were the primary casualty producing mechanisms among the crews of armored vehicles. With the advent of spall suppression liners, Flak vests, thermal protective clothing, and fire suppression systems, the threats from fragments and thermal have been reduced. Consequently, the vulnerability of personnel to blast overpressure, thermal, light flash, and smoke including toxic gases must be evaluated t expand existing lethality models and to possibly improve warhead design.
The objective of this report is to present information on the direct effects of blast (overpressure) produced behind armor by standard warheads and by detonating bare explosive charges.

K0336

AUTHOR Fletcher, E. R., Richmond, D. R., Babb, R. G., and Viney, J. F.

TITLE Characteristics of Plexiglas Fragments from Windows Broken by Airblast

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, prepared for Ballistic Research Laboratories, Aberdeen Proving Ground, MD, February 1974

ABSTRACT The airblast levels required to break plexiglas windows and the characteristics of the resultant fragments were studied. Square and rectangular panes of stretched, nonstretched, and laminated plexiglas of different sizes (0.7 to 8.0 sq ft) and thicknesses (1/16 to 1/3 inch) were exposed to several incident overpressure levels ranging from the threshold for breakage to about 5 and 9 psi for long (40-100 msec) and short-duration (10-20 msec) blast waves, respectively. Styrofoam witness plates were set to trap the fragments such that their velocities, masses, and numbers could be measured. The data were compared with earlier information on plexiglas in helicopters and shock-tube mock-ups exposed to blast waves of 280- to 440-msec duration. The biological effects of the various distributions of fragments were evaluated.

K0337

AUTHOR Richmond, D. R. and Fletcher, E. R.

TITLE The Effects of Air Blast on Sheep in Two-Man Foxholes, Project LN401 Operation Prairie Flat

SOURCE Preliminary Report, Lovelace Foundation for Medical Education and Research, in Operation Prairie Flat Symposium Report, pp 420-441, Volume I-Part II, January 1970

ABSTRACT Objective: The objective of this project was to determine the air blast protection that two-man foxholes afford a large biological specimen (sheep).

K0338

AUTHOR Richmond, D. R., Yelverton, J. T. and Fletcher, E. R.

TITLE New Airblast Criteria for Man

SOURCE Technical Paper, Life Sciences, Los Alamos National Laboratory, presented at the Twenty-Second DOD Explosives Safety Seminar, Anaheim, CA, 26-28 August 1986

ABSTRACT The purpose of this paper is to present new air blast criteria for man in the open and inside foxholes. The criteria for man in the open relate the incident blast overpressure as a function of positive duration required to produce mortality, lung injury, and graded levels of ear injury. These criteria were developed for man oriented side-on and end-on to the incident shock and for individuals against a reflecting surface normal to the incident shock. The criterion for man exposed to blast inside a foxhole relates the incident blast overpressure as a function of positive duration necessary to generate an LD50/2 blast level inside a foxhole oriented side-on. Information used in developing the new air blast criteria will be discussed.

K0339

AUTHOR Richmond, D. R.

TITLE Air Blast Criteria for Personnel In the Open

SOURCE Letter of transmittal w/enclosure, Lovelace Foundation for Medical Education and Research, submitted to Geophysical Fluid Dynamics Division, Sandia Laboratories, January 1973

ABSTRACT Includes draft criteria tables and illustrations for inclusion in Standard for Single Point Explosives in Air.

K0340

AUTHOR Richmond, D. R.

TITLE Exposure Inside an Enclosure

SOURCE Technical Paper, Life Sciences Division, Los Alamos National Laboratory, presented at Meetings at Establissement Technique de Bourges, NATO Panel VIII, RGS6 Group, Effects of Impulse Noise, Bourges, France, June 1987

ABSTRACT Introduction: Personnel can be exposed to blast inside an enclosure by the blast entering the enclosure from the outside or by the detonation of explosive materials inside the enclosure. This presentation will give a brief review of information on the effects from airblasts entering open structures and the results of recent experimentation dealing with the effects from detonating bare explosive charges inside enclosures, namely, armored vehicles.

K0341

AUTHOR Richmond, D. R.

TITLE The Effects of a 500-Ton Explosion on Goats, Program 4, Project 4.1, Suffield Experimental Station, Alberta, Canada - 1964

SOURCE Preliminary Report, Lovelace Foundation, in Appendix J, Minutes of the 4th Meeting, Panel N1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, Toronto, Canada, 28-30 Sep 1964

ABSTRACT Objectives: The primary objective of this project was to determine the tolerance (LD50) on goats located in the open to long-duration air-blast waves. Secondary objectives were (1) to record the time of death and the number of animals incapacitated as a function of time following their exposure and (2) to describe the nature of the blast injuries and attempt to relate them to the cause of death.

K0342

AUTHOR Richmond, D. R.

TITLE The Effects of Overpressure on Cattle, Program 4, Project 4.2, Suffield Experimental Station, Alberta, Canada - 1964

SOURCE Preliminary Report, Lovelace Foundation, in Appendix J, Minutes of the 4th Meeting, Panel N1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, Toronto, Canada, 28-30 Sep 1964

ABSTRACT Objectives: The objectives of this experiment were to determine the tolerance (LD50) of cattle exposed in the open to the airblast from a 500-ton charge of TNT, to determine the relationship between mortality and time following exposure and to describe the nature of the blast injuries and attempt to relate them to the causes of death or incapacitation.

K0343

AUTHOR Richmond, D. R.

TITLE The Effects of a 500-Ton Explosion on Goats in Foxholes, Program 4, Project 4.3, Suffield Experimental Station, Alberta, Canada - 1964

SOURCE Preliminary Report, Lovelace Foundation, in Appendix J, Minutes of the 4th Meeting, Panel N1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, Toronto, Canada, 28-30 Sep 1964

ABSTRACT Objectives: The objective of Project 4.3 was to compare the air-blast protection provided goats in simple, deep foxholes and in deep foxholes having an offset.

K0344

AUTHOR Richmond, D. R.

TITLE Threshold Lung Injury in Goats from a 500-Ton Explosion, Program 4, Project 4.4, Suffield Experimental Station, Alberta, Canada - 1964

SOURCE Preliminary Report, Lovelace Foundation, in Appendix J, Minutes of the 4th Meeting, Panel N1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, Toronto, Canada, 28-30 Sep 1964

ABSTRACT Objectives: The objective of this project was to obtain information on the blast pressures required for threshold lung injury in goats.

K0345

AUTHOR Richmond, D. R.

TITLE Translation of Goats and Anthropomorphic Dummies by Blast Waves, Program 4, Project 4.5, Suffield Experimental Station, Alberta, Canada - 1964

SOURCE Preliminary Report, Lovelace Foundation, in Appendix K, Minutes of the 4th Meeting, Panel N1 (Biomedical), Sub-Group N, Tripartite Technical Cooperation Program, Toronto, Canada, 28-30 Sep 1964

ABSTRACT Objectives: The objective of project 4.5 was to determine, by means of motion pictures, the time-displacement history of goats and anthropomorphic dummies. Velocity and acceleration, as functions of time, can be computed from measured displacements. The results will be compared to those obtained with a nuclear detonation and to those computed with a mathematical model using parameters of the blast wave of the displaced object as input.

K0346

AUTHOR Richmond, D. R.

TITLE Nature of Blast Injuries: Blast/Overpressure Criteria

SOURCE Technical Paper, EG&G Mason Research Institute, presented at Crew Casualty Assessment Workshop, Working Group IV: Blast Overpressure Report (no date)

ABSTRACT This paper contains an overview of the blast-produced injuries likely to be encountered: A. Airblast produced by conventional and fuel-air weapons and tactical nuclear weapons. B. Explosions in enclosed spaces, typically produced by shaped-charges in armored fighting vehicles (and, similarly, in ship's compartments). C. Blast overpressure in unsealed armored fighting vehicles resulting from large explosions with long duration pressure waves, typically produced by fuel-air munitions and tactical nuclear weapons.

K0347

AUTHOR Bowen, I. G.

TITLE Underwater Blast Swimmer Vulnerability

SOURCE Correspondence, Lovelace Foundation for Medical Education and Research, submitted to U.S. Naval Ordnance Laboratory, Silver Spring, MD, September 1968.

ABSTRACT Comments on swimmer vulnerability to underwater blast, review of literature.

K0348

AUTHOR Patterson, J.H., Jr., and Johnson, D. L.

TITLE Actual Effectiveness of Hearing Protection: U. S. Army Study

SOURCE Presented at Nice, France, 1993

ABSTRACT Exposure to high-intensity impulse noise produced by modern military weapons is known to be hazardous to hearing. Hearing protection is required to be worn by U.S. soldiers. However, there is no generally accepted theoretical way to predict whether protection will be adequate for the highest impulse noise levels. This led to an effort to empirically determine the safe limits of exposure to impulse noise when hearing protection is worn. Over the past several years, a series of studies has been conducted to determine the maximum safe exposure to high intensity, freefield impulse noise. These studies involved exposing human volunteers to a series of progressively more energetic impulses under controlled conditions. An exposure was considered to be save if it produced only a small temporary threshold shift (TTS <25 dB) in a small percentage of the volunteers exposed. Three different impulses were used with A-durations of 0.8, 1.4, and 2.9 ms. Both the level and number of impulses were varied to find the maximum tolerable exposure for combinations of these parameters. The peak sound pressure levels ranged up to 196 dB. The number of impulses was varied from 6 to 100 with 1 minute between impulses. Approximately 60 volunteers were exposed to each type of impulse wearing an earmuff that had been modified to simulate a poor fitting protector. This allowed high confidence estimates of the exposures that would produce no significant TTS in 95 percent of the exposed population. The results of these slides showed that, even with a relatively poor fitting earmuff, combinations of level and number of impulses which far exceed our currently accepted exposure limits could be tolerated by 95 percent of the volunteers. In addition to the studies using earmuffs, 19 volunteers were exposed wearing a perforated plug. The plug was degraded by a hole that allowed a free pathway between the outside of the protector and the external ear canal. This simulated a poor fit of an earplug protector. The real ear attenuation of the plug was similar to that of the muff except at 500 Hz where the muff provided about 8 dB more attenuation than the plug. The Noise Reduction Rating (NRR) of both protectors was about the same (1 dB for the plug and 3 dB for the muff). The actual performance of the devices was vastly different. The muff provided protection at impulse noise levels 6-13 dB higher than the plug.

K0349

AUTHOR Bowen, I. G.

TITLE Biological Scaling in Primary Blast

SOURCE Submitted as Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, Washington, DC, July 1965. Also presented at TTCP Meeting, Sub Group N, May 1965.

ABSTRACT Results of previous investigations in blast biology were mentioned as evidence of the oscillatory nature of the response of the thoraco-abominal system to air blast. A mathematical model designed to simulate this response was briefly described and some of the implications were discussed. Scaling equations were presented which had been derived from the model equations for similar animals and blast waves.
The scaling equations were applied in various ways to experimental data obtained by exposing animals at or near the end-plate of a shock tube and on the ground to overhead charges of high explosive. Concepts of animal similarity were discussed and evidence was presented indicating two groups of similar animals: (1) mouse, hamster, rat, guinea pig, and rabbit; and (2) cat, dog, and goat. Numerical solutions of the model were presented to help explain why animals received less blast damage if they were placed away from instead of against, the end-plate of a shock tube. The scaling equations for primary blast biology were combined with the usual scaling equations for air blast to determine the conditions of the equal biological response for similar animals of arbitrary mass exposed to overhead charges of high explosive. This type of scaling was tested using appropriate experimental data for six species of animals.
Estimates of the parameters of reflected blast waves resulting in 50 per cent mortality were made for 70-kg mammals (man) when the ambient pressure is 14.7 psi. These estimates were made by scaling appropriate data obtained for the dog and goat with an ambient pressure of 12 psi. Previous estimates of the tolerance of man to air blast wee compared to those of the present study.

K0350

AUTHOR

TITLE Behind Armor Effects Data Bases

SOURCE Rough draft report, KAFB.BAE 1987, Statistics Group, Los Alamos National Laboratory, March 1988

ABSTRACT The purpose of this report is to describe the data sets created from the series of Behind Armor Effects (BAE) tests performed at Kirtland Air Force Base. Digital data are recorded at the events. These data are converted to WX-11 to files which are stored on the Los Alamos Central Computing Facility. FORTRAN codes have been developed to convert the WX-11 file data to pressure, to find the start point of the test, to calculate impulses, and to plot the data. Several data bases are being developed from the Behind Armor Effects testing data.

K0351

AUTHOR Yelverton, J. T., Johnson, D. L., and Axelsson, H.

TITLE Review of Nonauditory Effects of Blast Overpressure

SOURCE Draft of Technical Paper, EG&G MSI, in Scientific Basis of Noise-Induced Hearing Loss, Chapter 36, (Axelsson, A., et al., Eds), Thieme Press, (no date)

ABSTRACT

K0352

AUTHOR Levy, W. J., Jones, R. K. and Rupprecht, F. C.

TITLE Combined Injury Bibliography - 1945 to 1965

SOURCE Lovelace Foundation for Medical Education and Research, prepared for Combined Nuclear Weapons Effects Study Working Group, 1965 (unpublished)

ABSTRACT The bibliography is medically oriented and covers the open literature from 1945 to about 1965.

K0353 DNA 4377P-2

AUTHOR

TITLE Proceedings of the Dice Throw Symposium, 21-23 June 1977

SOURCE Vols. 2 and 3, General Electric Company-TEMPO, DASIAC, Santa Barbara, CA, July 1977

ABSTRACT

K0354 POR 7158-4

AUTHOR

TITLE Proceedings of the Minor Scale Symposium, 24-28 February 1986

SOURCE Project Officers Report, Test Directorate, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, NM, 30 June 1986

ABSTRACT

K0355

AUTHOR

TITLE Proceedings of the Misers Bluff Phase II Results Symposium, 27-29 March 1979

SOURCE Vol. III, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, NM, 26 Sep 1979

ABSTRACT

K0356

AUTHOR

TITLE Proceedings Event Dial Pack Symposium Report

SOURCE Vol. II, The Technical Cooperation Program, Defence Research Board of Canada, Alberta, Canada, March 1971

ABSTRACT

K0357

AUTHOR

TITLE Proceedings of the Mixed Company/Middle Gust Results Meeting 13-15 March 1973

SOURCE Vol. I, Sessions 1, 2A, and 3A, General Electric Company-TEMPO, DASIAC, Santa Barbara, CA, 1 May 1973

ABSTRACT

K0358

AUTHOR

TITLE Proceedings of the Direct Course Symposium, 9-13 April 1984

SOURCE Project Officers Report, Test Directorate, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, NM, April 1984

ABSTRACT

K0359

AUTHOR Damon, E. G., Jones, R. K., Yelverton, J. T., Richmond, D. R., Hirsch, F. G., and White, C. S.

TITLE Biological Response to Integrated Effects of Radiation and Blast

SOURCE Technical Progress Report, Lovelace Foundation for Medical Education and Research, prepared for Defense Atomic Support Agency, April 1967

ABSTRACT Thirty-nine sheep, mounted side-on against the endplate of an air-driven shock tube, were exposed to "sharp"-rising reflected pressures of 212-msec duration. Pressure-time measurements were made with piezoelectric pressure transducers. Fatalities were autopsied soon after death and survivors were sacrificed at 60 days. The gross pathological findings were summarized and 24-hour and 60-day dose-response curves were obtained by probit analyses of the lethality data. The LD50 pressures for 24 hours and 60 days were 53.5 and 52.3 psi, respectively.

K0360

AUTHOR Chiffelle, T. L., Sherping, F., and White, C. S.

TITLE A Study of the Tissue Response to Sterile Subcutaneous Deposits of Particulate Material

SOURCE Technical Report, Lovelace Foundation for Medical Education and Research, prepared for the Atomic Energy Commission, Washington, DC, February 1954

ABSTRACT Introduction: This is the first report of the results of an investigation into the natural tissue response to foreign-body implants of selected material expected to occur in injuries resulting from an explosive event. The general scope of the work was presented in Project Report No.1 to the United States Atomic Energy Commission by the Lovelace Foundation, on October 15, 1952. The second phase of the project was concerned with the injurious effects on tissues and organs of a variety of secondary and tertiary missiles dislodged and set in motion by blast. Injuries resulting from such missiles would depend upon several factors: 1. The size of the material and the physico-chemical nature. 2. The site of impact and degree of displacement of the body as a whole or of its component parts. 3. The velocity of the missile, the degree of tissue disruption and penetration, and the amount of energy imparted to the tissue upon impact. The present report deals primarily with studies of the natural behavior of selected sterile foreign-body material, devoid of effects of physical energy, thermal energy, or ionizing radiation.

K0361

AUTHOR Richmond, D. R.

TITLE Blast Criteria for Open Spaces and Enclosures

SOURCE Presented at the XXI Nordic Congress of Military Medicine, Oslo, May-2-June 1990. In Scandinavian Supplementum 34, Effects of Noise and Blasts, (Ed. Hans M. Borchgrevink), June 1990.

ABSTRACT A review of the history of blast research is presented from before World War II to the present time. The mechanisms of blast injury and the nature of the injuries are described. Casualty criteria applicable to man's exposure to single blasts in open terrain as a function of overpressure duration and orientation are given. Damage-risk criteria for man exposed to repeated blasts of low and high intensity are described. The hazards from blast waves entering open structures are described with criteria for personnel located in a standard two-man open foxhole. Methods of establishing the air blast dose in a variety of exposure conditions are illustrated. The present state-of-the-art on personnel protection afforded by rigid and soft protective garments is given. Information on animal response to blast waves generated inside enclosures from the firing of recoilless weapons and the detonation of high-explosive charges is discussed along with the problem of defining the extent of performance decrement in relation to the air blast dose.

Section IV.

BOP Kirtland Database
Animal Information Report

Animal Information Report

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
1	K0108	Sheep	35	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Threshold
2	K0110	Sheep	64	Shock Tube, Open	Double Peak	High Explosive	Primary Blast	Threshold
3	K0111	Dummy	1	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
4	K0112	Man	10	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Threshold
5	K0114	Sheep	58	Shock Tube, Open	Reflected	High Explosive	Primary Blast	Threshold
6	K0116	Sheep	13	Shock Tube, Open	Reflected	High Explosive	Primary Blast	Threshold
7	K0179	Sheep	95	Complex	Single	Shaped Charge Warhead	Primary Blast	Severe
8	K0117	Sheep	51	Fragment		Air Gun	Secondary Blast	Severe
9	K0124	Model, Mathematical	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
10	K0045	Review				Nuclear	Primary Blast	
10	K0107	Review				Nuclear	Primary Blast	
11	K0151	Sheep	4	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
12	K0120		0	Friedlander	Single	High Explosive	Collateral Damage	
13	K0123	Model, Mathematical	0	Complex	Single	Nuclear	Tertiary Blast	Threshold
14	K0348	Man	0	Friedlander	Multiple	High Explosive	Auditory	Threshold
14	K0126	Man	0	Friedlander	Multiple	High Explosive	Auditory	Threshold
14	K0080	Man	0	Friedlander	Multiple	High Explosive	Auditory	Threshold
15	K0127	Review	0	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
16	K0127	Review	0	Friedlander	Multiple	High Explosive	Primary Blast	Severe
17	K0128	Sheep	16	Complex	Single	High Explosive	Primary Blast	Threshold
17	K0113	Sheep	16	Complex	Single	High Explosive	Primary Blast	Threshold
18	K0129	Sheep	32	Friedlander	Double Peak	High Explosive	Primary Blast	Severe
19	K0130	Rat	512				Combined Injury	LD50
20	K0131	Model, Mathematical	0	Friedlander	Single	Nuclear	Primary Blast	Threshold
21	K0131	Model, Mathematical	0	Friedlander	Single	Nuclear	Secondary Blast	Threshold
22	K0131	Model, Mathematical	0	Friedlander	Single	Nuclear	Tertiary Blast	Threshold
23	K0132	Sheep	40	Complex	Multiple	High Explosive	Primary Blast	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
24	K0282	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0278	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0279	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0280	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0277	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0281	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0276	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0283	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
24	K0284	Man	60	Complex	Multiple	High Explosive	Auditory	Threshold
25	K0133	Pig	4	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
26	K0133	Sheep	4	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
27	K0135	Sheep	31	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
28	K0137	Dummy	2	Complex	Single	High Explosive	Combined Injury	Severe
29	K0152	Sheep		Underwater	Single	High Explosive	Primary Blast	Threshold
30	K0167	Sheep	37	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Threshold
31	K0166	Review	0	Friedlander	Single	High Explosive	Primary Blast	Severe
32	K0169	Swine		Friedlander	Single	Shaped Charge Warhead	Secondary Blast	Severe
33	K0172	Dummy	6	Complex	Single	High Explosive	Tertiary Blast	Severe
34	L0176	Review	0	Complex	Single	High Explosive	Tertiary Blast	LD50
35	K0176	Review	0	Shock Tube, Open	Single	High Explosive	Primary Blast	LD50
36	K0201	Sheep	16	Complex	Single	Shaped Charge Warhead	Primary Blast	Severe
37	K0104	Man	10	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Threshold
38	K0177	Man	9	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
39	K0082	Model, mathematical	0	Complex	Single	Nuclear	Thermal	Severe
40		Review	0	Friedlander	Single	Nuclear	Tertiary Blast	LD50
40	K0235	Review	0	Friedlander	Single	Nuclear	Tertiary Blast	LD50
41	K0182	Sheep	44	Shock Tube, Closed	Single	Air Gun	Secondary Blast	Severe
42	K0184	Dummy	2	Friedlander	Single	High Explosive	Secondary Blast	Severe
43	K0185	Dummy	1	Complex	Single	High Explosive	Tertiary Blast	

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
44	K0186	Glass	0	Complex	Single	High Explosive	Secondary Blast	
45	K0195					High Explosive	Collateral Damage	
45	K0185					High Explosive	Collateral Damage	
46	K0031	Review	0	Friedlander	Single	Nuclear	Primary Blast	LD50
46	K0092	Review	0	Friedlander	Single	Nuclear	Primary Blast	LD50
47	K0031	Review	0	Friedlander	Single	Nuclear	Secondary Blast	LD50
47	K0092	Review	0	Friedlander	Single	Nuclear	Secondary Blast	LD50
48	K0189	Review	0	Complex	Single	High Explosive	Primary Blast	Threshold
49	K0191	Review	0	Complex	Single	High Explosive	Primary Blast	Threshold
50	K0190	Rat	269	Shock Tube, Closed	Multiple	Air-driven	Primary Blast	Threshold
51	K0190	Sheep	71	Shock Tube, Closed	Multiple	Air-driven	Primary Blast	Threshold
52	K0194	Duck	100	Underwater	Single	High Explosive	Primary Blast	Threshold
52	K0193	Duck	100	Underwater	Single	High Explosive	Primary Blast	Threshold
52	K0070	Duck	100	Underwater	Single	High Explosive	Primary Blast	Threshold
52	K0298	Duck	100	Underwater	Single	High Explosive	Primary Blast	Threshold
53	K0298	Sheep	110	Underwater	Single	High Explosive	Primary Blast	Threshold
53	K0193	Sheep	110	Underwater	Single	High Explosive	Primary Blast	Threshold
53	K0194	Sheep	110	Underwater	Single	High Explosive	Primary Blast	Threshold
53	K0070	Sheep	110	Underwater	Single	High Explosive	Primary Blast	Threshold
54	K0194	Dog	38	Underwater	Single	High Explosive	Primary Blast	Threshold
54	K0298	Dog	38	Underwater	Single	High Explosive	Primary Blast	Threshold
54	K0193	Dog	38	Underwater	Single	High Explosive	Primary Blast	Threshold
54	K0070	Dog	38	Underwater	Single	High Explosive	Primary Blast	Threshold
55	K0194	Monkey	6	Underwater	Multiple	High Explosive	Primary Blast	Threshold
55	K0070	Monkey	6	Underwater	Multiple	High Explosive	Primary Blast	Threshold
55	K0298	Monkey	6	Underwater	Multiple	High Explosive	Primary Blast	Threshold
55	K0193	Monkey	6	Underwater	Multiple	High Explosive	Primary Blast	Threshold
56	K0194	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
57	K0196	Sheep	16	Complex	Single	High Explosive	Primary Blast	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
58	K0197	Review	0	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
59	K0209	Dog	115	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
60	K0120	Plexiglas				High Explosive	Collateral Damage	
60	K0309	Plexiglas				High Explosive	Collateral Damage	
60	K0326	Plexiglas				High Explosive	Collateral Damage	
61	K0163	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
61	K0351	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
62	K0013	Review	0	Friedlander	Single	Nuclear	Primary Blast	LD50
62	K0225	Review	0	Friedlander	Single	Nuclear	Primary Blast	LD50
63	K0013	Review	0	Friedlander	Single	Nuclear	Secondary Blast	LD50
63	K0225	Review	0	Friedlander	Single	Nuclear	Secondary Blast	LD50
64	K0013	Review	0	Friedlander	Single	Nuclear	Tertiary Blast	LD50
64	K0225	Review	0	Friedlander	Single	Nuclear	Tertiary Blast	LD50
65	K0199	Review	0	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
66	K0312	Dummy, Anthropomorphic		Complex	Single	High Explosive	Primary Blast	Threshold
66	K0205	Dummy, Anthropomorphic		Complex	Single	High Explosive	Primary Blast	Threshold
67	K0202	Review	0	Complex	Multiple	High Explosive	Primary Blast	Threshold
68	K0068	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
68	K0079	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
69	K0068	Review	0	Friedlander	Single	Nuclear	Primary Blast	Threshold
69	K0079	Review	0	Friedlander	Single	Nuclear	Primary Blast	Threshold
70	K0002	Dummy, Anthropomorphic	6	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
71	K0203	Dummies, Anthropmorphic	6	Complex	Multiple	Ammonium-Nitrate Fuel-Oil	Tertiary Blast	Threshold
72	K0002	Bovine	24	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
73	K0207	Review	0	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
74	K0002	Goat	74	Friedlander	Single	High Explosive	Primary Blast	Mortality

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
75	K0002	Spheres, steel	0	Friedlander	Single	High Explosive	Tertiary Blast	
76	K0025	Goat	40	Friedlander	Single	High Explosive	Primary Blast	Threshold
76	K0086	Goat	40	Friedlander	Single	High Explosive	Primary Blast	Threshold
77	K0210	Mouse	240	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Mortality
78	K0210	Rat	60	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Mortality
79	K0210	Guinea Pig	177	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Mortality
80	K0210	Rabbit	84	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	LD50
81	K0211	Goat	45	Friedlander	Single	High Explosive	Primary Blast	Mortality
82	K0211	Rabbit	60	Friedlander	Single	High Explosive	Primary Blast	Mortality
83	K0211	Mouse	240	Friedlander	Single	High Explosive	Primary Blast	Mortality
84	K0211	Rat	310	Friedlander	Single	High Explosive	Primary Blast	Mortality
85	K0215	Dog	16	Shock Tube, Closed	Single	Air-driven	Primary Blast	Threshold
86	K0042	Spheres	0	Friedlander	Single	Nuclear	Tertiary Blast	
87	K0216	Rat	164	Shock Tube, Closed	Single	Air-driven	Primary Blast	Threshold
88	K0216	Mouse	140	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Subthreshold
89	K0216	Guinea Pig	96	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Threshold
90	K0216	Rabbit	104	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Threshold
91	K0216	Dog	35	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Threshold
92	K0216	Goat	30	Shock Tube, Closed	Single	Air, Compressed	Primary Blast	Threshold
93	K0217	Dog	14	Friedlander	Single	Air Gun	Secondary Blast	Severe
94	K0220	Review	0	Friedlander	Single	Nuclear	Primary Blast	Mortality
94	K0039	Review	0	Friedlander	Single	Nuclear	Primary Blast	Mortality
95	K0039	Review	0	Complex	Single	Nuclear	Secondary Blast	Mortality
95	K0220	Review	0	Complex	Single	Nuclear	Secondary Blast	Mortality
96	K0039	Review	0	Friedlander	Single	Nuclear	Tertiary Blast	Mortality
96	K0220	Review	0	Friedlander	Single	Nuclear	Tertiary Blast	Mortality
97	K0039	Review	0	Friedlander	Single	Nuclear	Radiation	Mortality
97	K0220	Review	0	Friedlander	Single	Nuclear	Radiation	Mortality
98	K0220	Review	0	Friedlander	Single	Nuclear	Thermal	Mortality

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
99	K0003	Guinea Pig	580	Shock Tube, Open	Single	Air-driven	Primary Blast	LD50
99	K0221	Guinea Pig	580	Shock Tube, Open	Single	Air-driven	Primary Blast	LD50
100	K0223	Model, mathematical	0	Friedlander	Single		Secondary Blast	
100	K0106	Model, mathematical	0	Friedlander	Single		Secondary Blast	
101	K0085	Rat	150	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
101	K0159	Rat	150	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
102	K0085	Mouse	200	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
102	K0159	Mouse	200	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
103	K0085	Guinea Pig	120	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
103	K0159	Guinea Pig	120	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
104	K0085	Rabbit	40	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
104	K0159	Rabbit	40	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
105	K0085	Dog	35	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
105	K0159	Dog	35	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
106	K0085	Goat	30	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
106	K0159	Goat	30	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
107	K0085	Bovine	27	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
107	K0159	Bovine	27	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
108	K0085	Sheep	39	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
108	K0159	Sheep	39	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
109	K0085	Cat	48	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
109	K0159	Cat	48	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
110	K0226	Review	0	Friedlander	Single	Nuclear	Primary Blast	LD50
111	K0226	Review	0	Friedlander	Single	Nuclear	Secondary Blast	Mortality
112	K0226	Review	0	Friedlander	Single	Nuclear	Tertiary Blast	Mortality
113	K0226	Review	0	Friedlander	Single	Nuclear	Radiation	Mortality
114	K0226	Review	0	Friedlander	Single	Nuclear	Thermal	Mortality
115	K0226	Review	0	Complex	Single	Nuclear	Primary Blast	Mortality
116	K0103	Rats	320	Shock Tube, Closed	Single	Air-driven	Combined Injury	LD50

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
116	K0227	Rats	320	Shock Tube, Closed	Single	Air-driven	Combined Injury	LD50
117	K0228	Dog	76	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
118	K0228	Goat	43	Shock Tube, Closed	Single	Air-driven	Primary Blast	Severe
119	K0228	Rats	211	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
120	K0228	Guinea Pig	225	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
121	K0001	Model, mathematical	0	Friedlander	Single	Nuclear	Tertiary Blast	
122	K0001	Model, mathematical	0	Friedlander	Single	High Explosive	Tertiary Blast	
123	K0046	Spheres	0	Drop Tests			Impact	
124	K0046	Stones	0	Drop Tests			Impact	
125	K0046	Debris	0	Drop Tests			Impact	
126	K0046	Steel Plates	0	Drop Tests			Impact	
127	K0003	Guinea Pig	308	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
127	K0221	Guinea Pig	308	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
128	K0046	Glass	0	Drop Tests			Impact	
129	K0012	Dog	66	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
129	K0008	Dog	66	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
130	K0012	Goat	43	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
130	K0008	Goat	43	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
131	K0008	Rat	211	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
131	K0012	Rat	211	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
132	K0008	Guinea Pig	132	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
132	K0012	Guinea Pig	132	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
133	K0010	Model, mathematical	0	Friedlander	Single		Primary Blast	
134	K0011	Mouse	240	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
135	K0011	Rat	160	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
136	K0011	Guinea Pig	177	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
137	K0011	Rabbit	84	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
138	K0012	Mouse	672	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
138	K0008	Mouse	672	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
139	K0014	Model, mathematical	0				Tertiary Blast	
140	K0015	Review	0	Shock Tube, Closed	Single	Air Gun	Primary Blast	LD50
141	K0073	Bird	20	Shock Tube, Closed	Single	Air-driven	Secondary Blast	LD50
142	K0073	Bird	34	Shock Tube, Closed	Single	Air-driven	Secondary Blast	LD50
143	K0073	Bird	53	Friedlander	Single	High Explosive	Primary Blast	LD50
144	K0204	Dummy, Anthropomorphic	0	Friedlander	Single	Fuel Air Explosive	Tertiary Blast	Threshold
145	K0229	Dummy, Anthropomorphic	2	Complex	Multiple	High Explosive	Tertiary Blast	Threshold
145	K0329	Dummy, Anthropomorphic	2	Complex	Multiple	High Explosive	Tertiary Blast	Threshold
146	K0016	Guinea Pig	118	Shock Tube, Open	Single	Air-driven	Primary Blast	LD50
147	K0017	Mouse	414	Friedlander	Single	High Explosive	Primary Blast	LD50
148	K0017	Rat	218	Friedlander	Single	High Explosive	Primary Blast	LD50
149	K0017	Guinea Pig	197	Friedlander	Single	High Explosive	Primary Blast	LD50
150	K0017	Rabbit	164	Friedlander	Single	High Explosive	Primary Blast	LD50
151	K0018	Guinea Pig	13	Friedlander	Single	High Explosive	Primary Blast	Threshold
152	K0019	Sheep	39	Shock Tube, Open	Single	Air-driven	Primary Blast	Threshold
153	K0020	Monkey	12				Radiation	Performance Decrement
154	K0021	Bovine	27	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
155	K0173	Monkey	12				Radiation	Performance Decrement
155	K0022	Monkey	12				Radiation	Performance Decrement
156	K0024	Sheep	24	Shock Tube, Closed	Single	Air-driven	Primary Blast	Threshold
157	K0024	Sheep	3	Friedlander	Single	High Explosive	Primary Blast	Threshold
158	K0024	Dog	7	Shock Tube, Closed	Single	Air-driven	Primary Blast	Threshold
159	K0086	Guinea Pig	136	Complex	Single	Nuclear	Primary Blast	Threshold
159	K0025	Guinea Pig	136	Complex	Single	Nuclear	Primary Blast	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
160	K0025	Rabbit	88	Complex	Single	Nuclear	Primary Blast	Threshold
160	K0086	Rabbit	88	Complex	Single	Nuclear	Primary Blast	Threshold
161	K0086	Dog	136	Friedlander	Single	Nuclear	Primary Blast	Threshold
161	K0025	Dog	136	Friedlander	Single	Nuclear	Primary Blast	Threshold
162	K0086	Dog	72	Shock Tube, Closed	Single	Air-driven	Primary Blast	Threshold
162	K0025	Dog	72	Shock Tube, Closed	Single	Air-driven	Primary Blast	Threshold
163	K0025	Swine	8	Complex	Single	Nuclear	Primary Blast	Threshold
163	K0086	Swine	8	Complex	Single	Nuclear	Primary Blast	Threshold
164	K0086	Goat	58	Friedlander	Single	High Explosive	Primary Blast	Threshold
164	K0025	Goat	58	Friedlander	Single	High Explosive	Primary Blast	Threshold
165	K0026	Sheep	10	Shock Tube, Closed	Single	Air-driven	Primary Blast	Threshold
166	K0027	Sheep	21	Shock Tube, Closed	Single	Air-driven	Combined Injury	LD50
167	K0028	Rat	36				Combined Injury	Threshold
168	K0030	Monkey	9				Radiation	Threshold
169	K0224	Mouse	193	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
169	K0034	Mouse	193	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
170	K0034	Rat	235	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
170	K0224	Rat	235	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
171	K0224	Guinea Pig	586	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
171	K0034	Guinea Pig	586	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
172	K0224	Rabbit	93	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
172	K0034	Rabbit	93	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
173	K0035	Dog	14	Friedlander	Single	Nuclear	Secondary Blast	Mortality
174	K0038	Mouse	350				Radiation	
175	K0041	Mouse	20	Complex	Single	Nuclear	Primary Blast	Threshold
176	K0042	Dummy, anthropomorphic	4	Friedlander	Single	Nuclear	Tertiary Blast	
177	K0043	Dog	24	Complex	Single	Nuclear	Primary Blast	Mortality
178	K0043	Rabbit	50	Complex	Single	Nuclear	Primary Blast	Mortality

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
179	K0043	Swine	8	Complex	Single	Nuclear	Thermal	Mortality
180	K0043	Guinea Pig	100	Complex	Single	Nuclear	Primary Blast	Mortality
181	K0043	Mouse	380	Complex	Single	Nuclear	Primary Blast	Mortality
182	K0044	Dog	66	Complex	Single	Nuclear	Primary Blast	Mortality
183	K0044	Rabbit	52	Complex	Single	Nuclear	Primary Blast	Mortality
184	K0044	Guinea Pig	52	Complex	Single	Nuclear	Primary Blast	Mortality
185	K0044	Rat	63	Complex	Single	Nuclear	Primary Blast	Mortality
186	K0044	Mouse	44	Complex	Single	Nuclear	Primary Blast	Mortality
187	K0046	Mouse	6	Freefall, drop test	Multiple		Impact	LD50
188	K0046	Rat	6	Freefall, drop tests			Impact	LD50
189	K0046	Guinea Pig	6	Freefall, drop tests			Impact	LD50
190	K0046	Rabbit	5	Freefall, drop tests			Impact	LD50
191	K0048	Model, mathematical	0				Tertiary Blast	
192	K0051	Model, mathematical	0	Underwater	Single	High Explosive	Primary Blast	Threshold
193	K0101	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
193	K0053	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
194	K0054	Dummy, anthropomorphic	6	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
195	K0055	Review	0	Friedlander	Single	High Explosive	Primary Blast	Mortality
196	K0057	Dummy, anthropomorphic	5	Complex	Single	High Explosive	Tertiary Blast	Severe
196	K0314	Dummy, anthropomorphic	5	Complex	Single	High Explosive	Tertiary Blast	Severe
197	K0058	Dummy, anthropomorphic	2	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
197	K0315	Dummy, anthropomorphic	2	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
198	K0069	Fish	910	Underwater	Single	High Explosive	Primary Blast	LD50
198	K0296	Fish	910	Underwater	Single	High Explosive	Primary Blast	LD50
198	K0235	Fish	910	Underwater	Single	High Explosive	Primary Blast	LD50

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
198	K0109	Fish	910	Underwater	Single	High Explosive	Primary Blast	LD50
199	K0059	Dog	204	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
200	K0059	Goat	115	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
201	K0059	Mouse	200	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
202	K0059	Hamster	110	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
203	K0059	Rat	150	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
204	K0059	Guinea Pig	120	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
205	K0059	Rabbit	40	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
206	K0059	Dog	60	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
207	K0062	Dummy, Anthropomorphic	1	Trench, slit	Single	High Explosive	Tertiary Blast	
208	K0060	Mouse	113	Drop Tests	Single		Impact	LD50
208	K0102	Mouse	113	Drop Tests	Single		Impact	LD50
209	K0060	Rat	178	Drop Tests	Single		Impact	LD50
209	K0102	Rat	178	Drop Tests	Single		Impact	LD50
210	K0102	Guinea Pig	111	Drop Tests	Single		Impact	LD50
210	K0060	Guinea Pig	111	Drop Tests	Single		Impact	LD50
211	K0060	Rabbit	53	Drop Tests	Single		Impact	LD50
211	K0102	Rabbit	53	Drop Tests	Single		Impact	LD50
212	K0061	Sheep	28	Foxhole	Single	High Explosive	Primary Blast	Threshold
212	K0337	Sheep	28	Foxhole	Single	High Explosive	Primary Blast	Threshold
213	K0062	Dummy, anthropomorphic	5	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
214	K0063	Guinea Pig	165	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
215	K0063	Rabbit	30	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
216	K0064	Rat	449	Shock Tube, Closed	Single	Air-driven	Combined Injury	Threshold
217	K0065	Monkey	18	Shock Tube, Closed	Single	Air-driven	Primary Blast	Performance Decrement
218	K0066	Monkey	39				Radiation	Physiology

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
219	K0099	Monkey	31				Radiation	Performance Decrement
219	K0067	Monkey	31				Radiation	Performance Decrement
220		Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
220	K0124	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
221	K0070	Sheep	110	Underwater	Single	High Explosive	Primary Blast	Threshold
222	K0070	Dog	38	Underwater	Single	High Explosive	Primary Blast	Threshold
223	K0070	Monkey	6	Underwater	Single	High Explosive	Primary Blast	Threshold
224	K0070	Duck	81	Underwater	Single	High Explosive	Primary Blast	Threshold
225	K0071	Rat	114				Combined Injury	Threshold
226	K0073	Bird	182	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
227	K0076	Dog	20	Shock Tube, Closed	Single	Air-driven	Primary Blast	Mortality
228	K0077	Sheep	92	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Mortality
229	K0077	Swine	44	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Mortality
230	K0078	Monkey	10				Radiation	Performance Decrement
231	K0240	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0260	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0259	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0258	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0248	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0257	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0256	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0080	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
231	K0348	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
232	K0081	Model, mathematical	0	Friedlander	Single	High Explosive	Tertiary Blast	
233								
234	K0083	Monkey	54				Radiation	Performance Decrement

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
235	K0022	Monkey	12				Radiation	Performance Decrement
235	K0173	Monkey	12				Radiation	Performance Decrement
236	K0330	Review	0	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
237	K0331	Glass	0			High Explosive	Secondary Blast	
238	K0332	Sheep	16	Complex	Multiple	High Explosive	Primary Blast	Subthreshold
239	K0333	Dummy, Anthropomorhic	4	Complex	Single	Ammonium Nitrate-Fuel Oil	Tertiary Blast	Mortality
240	K0299	Stone	0	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
241	K0299	Block	0	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
242	K0050	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
243	K0233	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
243	K0295	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
243	K0109	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
243	K0235	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
243	K0234	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
243	K0165	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
244	K0334	Dummy, Anthropomorphic	4	Complex	Single	High Explosive	Tertiary Blast	Threshold
245	K0371	Sheep	101	Underwater	Single	High Explosive	Primary Blast	Threshold
245	K0006	Sheep	101	Underwater	Single	High Explosive	Primary Blast	Threshold
245	K0230	Sheep	101	Underwater	Single	High Explosive	Primary Blast	Threshold
246	K0006	Dog	37	Underwater	Single	High Explosive	Primary Blast	Threshold
247	K0006	Monkey	6	Underwater	Single	High Explosive	Primary Blast	Threshold
248	K0335	Sheep	65	Complex	Single	Shaped Charge Warhead	Primary Blast	LD50
249	K0335	Sheep	65	Complex	Single	High Explosive	Primary Blast	LD50
250	K0336	Fragments	0			Sabot	Secondary Blast	Threshold
251	K0061	Sheep	28	Foxhole	Single	High Explosive	Primary Blast	Threshold
251	K0337	Sheep	28	Foxhole	Single	High Explosive	Primary Blast	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
252	K0338	Review	0	Friedlander	Single	High Explosive	Primary Blast	Mortality
253	K0086	Review	0	Friedlander	Single	Nuclear	Primary Blast	Threshold
254								
255	K0339	Dummies, anthropomorphic		Complex	Single	High Explosive	Tertiary Blast	LD50
256	K0339	Dummies, anthropomorphic		Complex	Single	High Explosive	Impact	LD50
257	K0340	Review	0	Complex	Single	High Explosive	Primary Blast	LD50
258	K0340	Review	0	Complex	Single	High Explosive	Tertiary Blast	LD50
259	K0002	Goats	35	Friedlander	Single	High Explosive	Primary Blast	LD50
259	K0341	Goats	35	Friedlander	Single	High Explosive	Primary Blast	LD50
260	K0088	Dog	4	Electromagnetic Pulse				Performance Decrement
261	K0087	Model, mathematical	0				Primary Blast	
262	K0088	Monkey	2	Electromagnetic Pulse				Performance Decrement
263	K0089	Sheep	33	Shock Tube, Closed	Single	Air-driven	Primary Blast	Severe
264	K0089	Dog	7	Shock Tube, Closed	Single	Air-driven	Primary Blast	Severe
265	K0089	Sheep	3	Friedlander	Single	High Explosive	Primary Blast	Severe
266								
267								
268								
269	K0060	Rat	178	Drop Tests			Tertiary Blast	Mortality
269	K0102	Rat	178	Drop Tests			Tertiary Blast	Mortality
270	K0091	Model, mathematical	0				Primary Blast	
271	K0094	Model, mathematical	0	Complex	Multiiple	High Explosive	Primary Blast	
272	K0098	Monkey	9				Radiation	Performance Decrement
273	K0099	Monkey	16				Radiation	Performance Decrement

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
273	K0067	Monkey	16				Radiation	Performance Decrement
274	K0102	Mouse	113	Drop Tests			Tertiary Blast	Mortality
274	K0060	Mouse	113	Drop Tests			Tertiary Blast	Mortality
275	K0060	Guinea Pig	111	Drop Tests			Tertiary Blast	Mortality
275	K0102	Guinea Pig	111	Drop Tests			Tertiary Blast	Mortality
276	K0102	Rabbit	54	Impact			Tertiary Blast	Mortality
276	K0060	Rabbit	54	Impact			Tertiary Blast	Mortality
277	K0103	Rat	320	Shock Tube, Closed	Single	Air-driven	Combined Injury	LD50
277	K0227	Rat	320	Shock Tube, Closed	Single	Air-driven	Combined Injury	LD50
278								
279	K0105	Sheep	650	Friedlander	Multiple	High Explosive	Primary Blast	Threshold
280	K0223	Model, mathematical	0				Primary Blast	LD50
280	K0106	Model, mathematical	0				Primary Blast	LD50
281	K0223	Dog	45	Impact	Single	Air Gun	Secondary Blast	LD50
281	K0106	Dog	45	Impact	Single	Air Gun	Secondary Blast	LD50
282	K0097	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold-Eardrum
283	K0224	Rat	225	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
283	K0034	Rat	225	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
284	K0034	Rabbit	93	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
284	K0224	Rabbit	93	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
285	K0034	Guinea Pig	586	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
285	K0224	Guinea Pig	586	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
286								
287	K0342	Bovine	24	Friedlander	Single	High Explosive	Primary Blast	Mortality
287	K0002	Bovine	24	Friedlander	Single	High Explosive	Primary Blast	Mortality
288	K0234	Sheep	242	Underwater	Single	High Explosive	Primary Blast	Threshold
288	K0109	Sheep	242	Underwater	Single	High Explosive	Primary Blast	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
288	K0295	Sheep	242	Underwater	Single	High Explosive	Primary Blast	Threshold
288	K0165	Sheep	242	Underwater	Single	High Explosive	Primary Blast	Threshold
288	K0297	Sheep	242	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0109	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0235 K0235	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0231	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0231	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0297	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0165	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0295	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0234	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0235	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
289	K0069	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
290	K0235	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
290	K0070	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
291								
292	K0343	Goat	18	Foxhole	Single	High Explosive	Primary Blast	Threshold
292	K0002	Goat	18	Foxhole	Single	High Explosive	Primary Blast	Threshold
293	K0237	Model, mathematical	0	Underwater	Single	High Explosive	Primary Blast	Mortality
294	K0238	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
295	K0239	Sheep	6	Underwater	Single	High Explosive	Primary Blast	Threshold
296	K0240	Man	273	Friedlander	Multiple	High Explosive	Auditory	Threshold
297	K0241	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
297	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
298	K0242	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
298	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
299	K0243	Man	4	Friedlander	Multiple	High Explosive	Auditory	Threshold
299	K0240	Man	4	Friedlander	Multiple	High Explosive	Auditory	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
300	K0244	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
300	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
301	K0245	Man	13	Friedlander	Multiple	High Explosive	Auditory	Threshold
301	K0240	Man	13	Friedlander	Multiple	High Explosive	Auditory	Threshold
302	K0246	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
302	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
303	K0247	Man	14	Friedlander	Multiple	High Explosive	Auditory	Threshold
303	K0240	Man	14	Friedlander	Multiple	High Explosive	Auditory	Threshold
304	K0248	Man	6	Friedlander	Multiple	High Explosive	Auditory	Threshold
304	K0240	Man	6	Friedlander	Multiple	High Explosive	Auditory	Threshold
305	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
305	K0249	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
306	K0240	Man	9	Friedlander	Multiple	High Explosive	Auditory	Threshold
306	K0250	Man	9	Friedlander	Multiple	High Explosive	Auditory	Threshold
307	K0240	Man	14	Friedlander	Multiple	High Explosive	Auditory	Threshold
307	K0251	Man	14	Friedlander	Multiple	High Explosive	Auditory	Threshold
308	K0252	Man	14	Friedlander	Multiple	High Explosive	Auditory	Threshold
308	K0240	Man	14	Friedlander	Multiple	High Explosive	Auditory	Threshold
309	K0240	Man	10	Friedlander	Multiple	High Explosive	Auditory	Threshold
309	K0253	Man	10	Friedlander	Multiple	High Explosive	Auditory	Threshold
310	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
310	K0254	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
311	K0255	Man	7	Friedlander	Multiple	High Explosive	Auditory	Threshold
311	K0240	Man	7	Friedlander	Multiple	High Explosive	Auditory	Threshold
312	K0240	Man	4	Friedlander	Multiple	High Explosive	Auditory	Threshold
312	K0256	Man	4	Friedlander	Multiple	High Explosive	Auditory	Threshold
313	K0240	Man	6	Friedlander	Multiple	High Explosive	Auditory	Threshold
313	K0257	Man	6	Friedlander	Multiple	High Explosive	Auditory	Threshold
314	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
314	K0258	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
315	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
315	K0259	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
316	K0240	Man	11	Friedlander	Multiple	High Explosive	Auditory	Threshold
316	K0260	Man	11	Friedlander	Multiple	High Explosive	Auditory	Threshold
317	K0261	Man	13	Friedlander	Multiple	High Explosive	Auditory	Threshold
317	K0240	Man	13	Friedlander	Multiple	High Explosive	Auditory	Threshold
318	K0262	Man	10	Friedlander	Multiple	High Explosive	Auditory	Threshold
318	K0240	Man	10	Friedlander	Multiple	High Explosive	Auditory	Threshold
319	K0263	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
319	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
320	K0264	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
320	K0240	Man	12	Friedlander	Multiple	High Explosive	Auditory	Threshold
321	K0240	Man	6	Friedlander	Multiple	High Explosive	Auditory	Threshold
321	K0265	Man	6	Friedlander	Multiple	High Explosive	Auditory	Threshold
322	K0266	Man	13	Friedlander	Multiple	High Explosive	Auditory	Threshold
322	K0240	Man	13	Friedlander	Multiple	High Explosive	Auditory	Threshold
323	K0240	Man	10	Friedlander	Multiple	High Explosive	Auditory	Threshold
323	K0267	Man	10	Friedlander	Multiple	High Explosive	Auditory	Threshold
324	K0268	Dummy, Anthropmorphic	1	Friedlander	Multiple	High Explosive	Auditory	Threshold
324	K0240	Dummy, Anthropmorphic	1	Friedlander	Multiple	High Explosive	Auditory	Threshold
325	K0269	Sheep	129	Complex	Multiple	High Explosive	Primary Blast	Threshold
326	K0270	Sheep	110	Complex	Multiple	High Explosive	Primary Blast	Subthreshold
327	K0272	Sheep	150	Complex	Multiple	High Explosive	Primary Blast	Subthreshold
327	K0269	Sheep	150	Complex	Multiple	High Explosive	Primary Blast	Subthreshold
327	K0271	Sheep	150	Complex	Multiple	High Explosive	Primary Blast	Subthreshold
328	K0272	Sheep	150	Complex	Multiple	High Explosive	Primary Blast	Subthreshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
329	K0273	Sheep	19	Complex	Multiple	High Explosive	Primary Blast	Subthreshold
330	K0274	Sheep	150	Complex	Multiple	High Explosive	Primary Blast	Threshold
331	K0274	Sheep		Complex	Multiple	High Explosive	Primary Blast	Subthreshold
332	K0274	Sheep		Complex	Multiple	High Explosive	Primary Blast	Suprathreshold
333	K0344	Goats	25	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
333	K0373	Goats	25	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
333	K0002	Goats	25	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
334	K0275	Sheep	150	Complex	Multiple	High Explosive	Primary Blast	Subthreshold
335	K0276	Man	27	Complex	Multiple	High Explosive	Auditory	Threshold
336	K0277	Man	8	Complex	Multiple	High Explosive	Auditory	Threshold
336	K0276	Man	8	Complex	Multiple	High Explosive	Auditory	Threshold
337	K0278	Man	8	Complex	Multiple	High Explosive	Auditory	Threshold
337	K0276	Man	8	Complex	Multiple	High Explosive	Auditory	Threshold
338	K0276	Man	7	Complex	Multiple	High Explosive	Auditory	Threshold
338	K0279	Man	7	Complex	Multiple	High Explosive	Auditory	Threshold
339	K0276	Man	6	Complex	Multiple	High Explosive	Auditory	Threshold
339	K0280	Man	6	Complex	Multiple	High Explosive	Auditory	Threshold
340	K0276	Man	13	Complex	Multiple	High Explosive	Auditory	Threshold
340	K0281	Man	13	Complex	Multiple	High Explosive	Auditory	Threshold
341	K0276	Man	11	Complex	Multiple	High Explosive	Auditory	Threshold
341	K0282	Man	11	Complex	Multiple	High Explosive	Auditory	Threshold
342	K0276	Man	10	Complex	Multiple	High Explosive	Auditory	Threshold
342	K0283	Man	10	Complex	Multiple	High Explosive	Auditory	Threshold
343	K0284	Man	11	Complex	Multiple	High Explosive	Auditory	Threshold
343	K0276	Man	11	Complex	Multiple	High Explosive	Auditory	Threshold
344	K0276	Man	13	Complex	Multiple	High Explosive	Auditory	Threshold
344	K0285	Man	13	Complex	Multiple	High Explosive	Auditory	Threshold
345	K0286	Man	14	Complex	Multiple	High Explosive	Auditory	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
345	K0276	Man	14	Complex	Multiple	High Explosive	Auditory	Threshold
346	K0287	Goat	234	Friedlander	Single	Fuel Air Explosive	Primary Blast	Severe
347	K0287	Sheep	103	Friedlander	Single	Fuel Air Explosive	Primary Blast	Severe
348	K0287	Bovine	11	Friedlander	Single	Fuel Air Explosive	Primary Blast	Severe
349								
350	K0287	Sheep	103	Foxhole	Single	Fuel Air Explosive	Primary Blast	Severe
351	K0287	Goat	224	Foxhole	Single	Fuel Air Explosive	Primary Blast	Severe
352	K0292	Review	0	Complex	Single	Fuel Air Explosive	Combined Injury	Severe
352	K0288	Review	0	Complex	Single	Fuel Air Explosive	Combined Injury	Severe
353	K0288	Review	0	Complex	Single	Fuel Air Explosive	Thermal	Severe
353	K0292	Review	0	Complex	Single	Fuel Air Explosive	Thermal	Severe
354	K0289	Monkey	25	Friedlander	Single	Fuel Air Explosive	Primary Blast	Threshold
355	K0289	Monkey	115	Complex	Single	Fuel Air Explosive	Primary Blast	Threshold
356	K0290	Review	0			Fuel Air Explosive	Collateral Damage	
357	K0291	Dummy, anthropomorphic	10	Complex	Single	Fuel Air Explosive	Primary Blast	Threshold
358	K0291	Dummy, anthropomorphic	10	Friedlander	Single	Fuel Air Explosive	Secondary Blast	Threshold
359	K0291	Dummy, anthropomorphic	10	Friedlander	Single	Fuel Air Explosive	Tertiary Blast	Threshold
360	K0291	Dummy, anthropomorphic	10	Complex	Single	Fuel Air Explosive	Primary Blast	Threshold
361	K0291	Dummy, anthropomorphic	10	Complex	Single	Fuel Air Explosive	Secondary Blast	Threshold
362	K0291	Dummy, anthropomorphic	10	Complex	Single	Fuel Air Explosive	Tertiary Blast	Threshold
363	K0291	Dummy, anthropomorphic	10	Complex	Single	Fuel Air Explosive	Thermal	Threshold
364	K0288	Review	0	Friedlander	Single	Fuel Air Explosive	Primary Blast	Threshold
364	K0292	Review	0	Friedlander	Single	Fuel Air Explosive	Primary Blast	Threshold
365	K0288	Review	0	Friedlander	Single	Fuel Air Explosive	Secondary Blast	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
365	K0292	Review	0	Friedlander	Single	Fuel Air Explosive	Secondary Blast	Threshold
366	K0292	Review	0	Friedlander	Single	Fuel Air Explosive	Tertiary Blast	Threshold
366	K0288	Review	0	Friedlander	Single	Fuel Air Explosive	Tertiary Blast	Threshold
367	K0292	Review	0	Friedlander	Single	Fuel Air Explosive	Thermal	Threshold
367	K0288	Review	0	Friedlander	Single	Fuel Air Explosive	Thermal	Threshold
368	K0294	Sheep		Underwater	Single	High Explosive	Primary Blast	Threshold
369	K0295	Man	1	Underwater	Single	High Explosive	Primary Blast	Threshold
369	K0109	Man	1	Underwater	Single	High Explosive	Primary Blast	Threshold
369	K0165	Man	1	Underwater	Single	High Explosive	Primary Blast	Threshold
370	K0296	Fish	777	Underwater	Single	High Explosive	Primary Blast	Threshold
370	K0109	Fish	777	Underwater	Single	High Explosive	Primary Blast	Threshold
370	K0069	Fish	777	Underwater	Single	High Explosive	Primary Blast	Threshold
370	K0235	Fish	777	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0234	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0006	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0230	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0194	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0193	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0297	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0070	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0109	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
371	K0235	Review	0	Underwater	Single	High Explosive	Primary Blast	Threshold
372	K0298	Sheep	101	Underwater	Single	High Explosive	Primary Blast	Threshold
373	K0002	Dummy, anthropomorphic	6	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
373	K0345	Dummy, anthropomorphic	6	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
374	K0002	Goat	3	Friedlander	Single	High Explosive	Tertiary Blast	Mortality
374	K0345	Goat	3	Friedlander	Single	High Explosive	Tertiary Blast	Mortality

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
375	K0347	Sheep	120	Friedlander	Single	Fuel Air Explosive	Primary Blast	LD50
376	K0309	Fragment	0			High Explosive	Collateral Damage	
377	K0310	Sheep	28	Complex	Single	High Explosive	Primary Blast	LD50
378	K0311	Dummy, anthropomorphic	7	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
379	K0315	Dummy, anthropomorphic	3	Complex	Single	High Explosive	Tertiary Blast	Threshold
379	K0314	Dummy, anthropomorphic	3	Complex	Single	High Explosive	Tertiary Blast	Threshold
380	K0316	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
381	K0317	Dummy, anthropomorphic		Friedlander	Single	High Explosive	Tertiary Blast	Threshold
382	K0319	Dummy, anthropomorphic	10	Complex	Single	High Explosive	Tertiary Blast	Threshold
383	K0033	Swine	7	Friedlander	Single	Nuclear	Thermal	Mortality
384	K0047	Model, mathematical	0	Friedlander	Single	Nuclear		
385	K0052	Spheres		Friedlander	Single	Nuclear	Tertiary Blast	
386	K0072	Model, mathematical	0		Single	High Explosive	Secondary Blast	LD50
387	K0075	Fragment	0				Secondary Blast	P50
388	K0095	Sheep		Friedlander	Single	High Explosive	Combined Injury	Threshold
389	K0100	Monkey					Pseudomatching	
390								
391	K0107	Review	0	Friedlander	Single	Nuclear	Combined Injury	LD50
392								
393								
394								
395	K0113	Sheep	18	Complex	Single	High Explosive	Primary Blast	Threshold
396	K0113	Dummy, anthropomorphic	1	Complex	Single	High Explosive	Primary Blast	Threshold
397	K0115	Model, mathematical	0	Complex	Single	Shaped Charge Warhead	Primary Blast	Threshold

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
398	K0359	Sheep	39	Shock Tube, Closed	Single	Air-driven	Primary Blast	LD50
399	K0122	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
400	K0122	Review	0	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
401	K0124	Model, mathematical	0	Friedlander	Single	High Explosive	Primary Blast	LD50
402	K0138	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
404	K0142	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
405	K0144	Sheep		Friedlander	Single	High Explosive	Primary Blast	Threshold
406	K0151	Sheep	12	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Threshold
407	K0163	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
408	K0165	Man	1	Underwater	Single	High Explosive	Primary Blast	Threshold
409								
410	K0173	Sheep	12	Underwater	Single	High Explosive	Primary Blast	Threshold
411	K0187	Dummy, anthropomorphic	1	Complex	Single	High Explosive	Tertiary Blast	Threshold
412	K0347	Sheep	20	Complex	Single	Fuel Air Explosive	Primary Blast	LD50
413	K0347	Dummy, anthropomorphic	20	Friedlander	Single	Fuel Air Explosive	Tertiary Blast	LD50
414	K0222	Review	0	Friedlander	Single		Primary Blast	Threshold
415	K0225	Review	0	Complex	Single	Nuclear	Primary Blast	Threshold
416	K0225	Review	0	Complex	Single	High Explosive	Primary Blast	Threshold
417	K0321	Sheep		Complex	Single	High Explosive	Primary Blast	Threshold
418	K0321	Dummy, anthropomorphic		Complex	Single	High Explosive	Primary Blast	Threshold
419	K0322	Dummy, anthropomorphic	40	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
420	K0324	Review	0	Friedlander	Single	Fuel Air Explosive	Primary Blast	Mortality
421								
422								
423	K0423	Review	0	Friedlander	Single	Nuclear	Primary Blast	LD50
423	K0346	Review	0	Friedlander	Single	Nuclear	Primary Blast	LD50

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
424	K0329	Dummy, anthropomorphic	4	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
425	K0329	Dummy, anthropomorphic	4	Complex	Single	High Explosive	Tertiary Blast	Threshold
426	K0110	Sheep	36	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
427	K0112	Dummy	1	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Threshold
428	K0113	Sheep	18	Complex	Single	High Explosive	Primary Blast	Threshold
429	K0113	Sheep	6	Friedlander	Single	High Explosive	Primary Blast	Threshold
430	K0125	Dogs	34	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
430	K0161	Dogs	34	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
431	K0161	Monkeys	8	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
431	K0125	Monkeys	8	Shock Tube, Open	Single	High Explosive	Primary Blast	Threshold
432	K0155	Sheep	10	Shock Tube, Open	Multiple	High Explosive	Primary Blast	Threshold
433	K0346	Review	0	Friedlander	Single	High Explosive	Primary Blast	LD50
434	K0179	Sheep	95	Complex	Single	Shaped Charge Warhead	Primary Blast	Threshold
435	K0195	Dummy, Anthropomorphic	1	Friedlander	Single	High Explosive	Tertiary Blast	Threshold
436	K0195	Fragments, glass	0	Friedlander	Single	High Explosive	Secondary Blast	Threshold
437	K0159	Hamster	110	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
437	K0085	Hamster	110	Shock Tube, Closed	Single	High Explosive	Primary Blast	LD50
438	K0159	Mouse	120	Friedlander	Reflected	High Explosive	Primary Blast	LD50
438	K0085	Mouse	120	Friedlander	Reflected	High Explosive	Primary Blast	LD50
439	K0159	Rat	40	Friedlander	Reflected	High Explosive	Primary Blast	LD50
439	K0085	Rat	40	Friedlander	Reflected	High Explosive	Primary Blast	LD50
440	K0159	Guinea Pig	82	Friedlander	Reflected	High Explosive	Primary Blast	LD50
440	K0085	Guinea Pig	82	Friedlander	Reflected	High Explosive	Primary Blast	LD50
441	K0159	Rabbit	70	Friedlander	Reflected	High Explosive	Primary Blast	LD50
441	K0085	Rabbit	70	Friedlander	Reflected	High Explosive	Primary Blast	LD50
442	K0159	Monkey	12	Friedlander	Reflected	High Explosive	Primary Blast	LD50
442	K0085	Monkey	12	Friedlander	Reflected	High Explosive	Primary Blast	LD50

Animal ID	Citation Number	Model	No. of Animal	Blast Exposure	Blast Wave	Blast Source	Injury Type	Injury Level
443	K0085	Dog	29	Friedlander	Reflected	High Explosive	Primary Blast	LD50
443	K0159	Dog	29	Friedlander	Reflected	High Explosive	Primary Blast	LD50
444	K0159	Goat	15	Friedlander	Reflected	High Explosive	Primary Blast	LD50
444	K0085	Goat	15	Friedlander	Reflected	High Explosive	Primary Blast	LD50
445	K0159	Sheep	57	Friedlander	Reflected	High Explosive	Primary Blast	LD50
445	K0085	Sheep	57	Friedlander	Reflected	High Explosive	Primary Blast	LD50
446	K0085	Swine	16	Friedlander	Reflected	High Explosive	Primary Blast	LD50
446	K0159	Swine	16	Friedlander	Reflected	High Explosive	Primary Blast	LD50
447	K0349	Model, mathematical	0	Friedlander	Single	High Explosive	Primary Blast	LD50
448	K0346	Review	0	Friedlander	Single	Fuel Air Explosive	Primary Blast	LD50
449	K0346	Review	0	Complex	Single	Fuel Air Explosive	Primary Blast	LD50
450	K0346	Review	0	Complex	Single	Shaped Charge Warhead	Primary Blast	LD50
451	K0351	Review	0	Friedlander	Single	High Explosive	Primary Blast	Threshold
452	K0351	Review	0	Complex	Single	High Explosive	Primary Blast	Threshold